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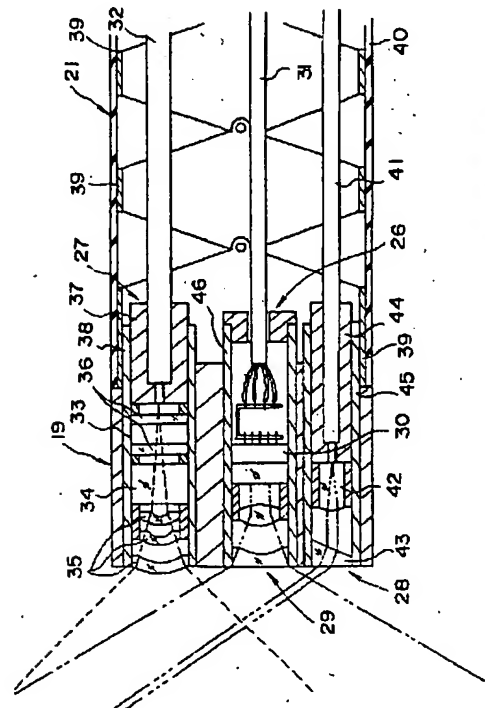
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(54)【発明の名称】計測用内視鏡装置

(57)【要約】

【目的】 煩雑なキャリブレーションを必要とせず、立体形状を精度よく、かつ迅速に求めることができる計測用内視鏡装置を提供すること。

【構成】 被検体像を撮像する撮像ユニット26と、被検体に対して3次元情報を得るための干渉縞を照射する干渉縞投影ユニット27と、内視鏡の挿入部先端から被検体までの距離を計測するための輝点を投影するレーザースポット投影ユニット28と、被検体に形成された干渉縞と測距情報に基づいて被検体の3次元情報を演算するコンピュータなどを具備している。



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【特許請求の範囲】

【請求項 1】 被検体像を撮像する撮像手段と、
前記被検体に対して干渉縞を照射する干渉縞照射手段と、
内視鏡の挿入部先端から被検体までの距離を測定する測距手段と、
前記測距手段の測距情報に基づいて前記被検体の 3 次元情報を演算する演算手段と、
を具備したことを特徴とする計測用内視鏡装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、内視鏡の先端から被検体までの距離を測定する測距手段を備えた計測用内視鏡装置に関する。

【0002】

【従来技術】近年、体腔内に細長の挿入部を挿入することにより体腔内臓器等を観察したり、必要に応じて処置具チャンネル内に挿通した処置具を用いて各種治療処置のできる内視鏡が広く用いられている。また、工業分野においても、ボイラー、タービン、エンジン、化学プラント等の内部のキズ、腐食等の観察、検査に工業用内視鏡が広く用いられている。

【0003】特開昭 59-69721 に、内視鏡先端部に測長用のビーム光を放射する手段が示されている。また、特開昭 62-73223 には一本のレーザー光線による測距手段が示されている。特開昭 64-49542 に体内の臓器表面等の凹凸を計測する計測内視鏡として、回析格子によるレーザー光の回析パターンを利用したものが示されている。

【0004】この回析パターンは投影レンズによって被測定物表面上に投影され、この投影像を視差のある位置から固体撮像素子等の撮像素子で観察すると、ラインあるいはドット状パターンは表面の凹凸形状に応じて変形して見える。そのため、撮像素子の画像信号に基づいて、被測定物表面上のライン状パターンの各明部に関して基準位置からの明度の変位量を演算することにより、物体表面の凹凸形状を計測することができるというものである。また、公知事実として干渉縞を物体表面に投影し、前記干渉縞を走査して測定精度を向上させる手法が有る。

【0005】

【発明が解決しようとする問題点】特開昭 64-49542 はドット状パターンのピッチで計測精度が決まる。精度を向上させるにはピッチを細かくしなければならないが、パターン投影光学系の大きさやパターン照射範囲等を考慮するとピッチ幅に限界があり高精度な計測はできない。

【0006】これに対して、干渉縞走査方法による形状測定では干渉縞の縞ピッチの約 1/50 程度の測定精度が得られるが、基準寸法（物体距離または、物体面上の

縞間隔あるいは、既知の形状測定によるキャリブレーション）を入力しなければ 3 次元形状の絶対値（実寸法）を得ることができない。しかし、一般に内視鏡による形状測定では機械内部の計測が主な目的となるため、あらかじめ物体距離等の基準寸法を知ることができず物体距離の入力や、キャリブレーション等を行うことができない。

【0007】本発明は上記事情に鑑みてなされたものであり、煩雑なキャリブレーションを必要とせず、立体形状を精度よく、かつ迅速に求めることができる計測用内視鏡装置を提供することを目的とする。

【0008】

【問題点を解決する手段および作用】本発明では被検体像を撮像する撮像手段と、被検体に対して干渉縞を照射する干渉縞照射手段と、内視鏡の挿入部先端から被検体までの距離を測定する測距手段と、この測距手段の測距情報に基づいて被検体の 3 次元情報を演算する演算手段とを具備することにより、測距手段の測距情報と干渉縞に基づいて前記演算手段により被検体の 3 次元情報を演算で求められるようにして、煩雑なキャリブレーションを必要とせず、立体形状を精度よく求めることができる。

【0009】

【実施例】以下、図面を参照して本発明の実施例を具体的に説明する。図 1 ないし図 6 は本発明の第 1 実施例に係り、図 1 は内視鏡装置の全体構成の説明図、図 2 は内視鏡先端部の断面図、図 3 は 3 次元計測の概要図、図 4 は干渉縞による計測の原理図、図 5 はレーザスポットによる測距方法の原理図、図 6 はレーザ光源のブロック図を示す。

【0010】図 1 に示すように、本発明の第 1 実施例の計測用内視鏡装置 1 は計測用の電子内視鏡 2 と、この電子内視鏡 2 が接続される照明用光源 3 及びカメラコントロールユニット（以下 CCU）4 と、前記 CCU 4 に接続され、3 次元情報を演算などするコンピュータ 5 と、コンピュータ 5 からの画像を表示するモニタ 6 及び 3 次元情報を得るための干渉縞を投影すると共に、測距のための輝点を投影するレーザ光源 7 を備えている。

【0011】上記電子内視鏡 2 は、細長の挿入部 11 と、この挿入部 11 の後端に連設された太幅の操作部 12 とを有し、この操作部 12 から外部に延出されたユニバーサルケーブル 13 の先端に設けられた光源コネクタ 14 を照明用光源 3 に着脱自在で装着することができる。このコネクタ 14 から信号ケーブル 15 と光ケーブル 16 とが延出され、それぞれの端部に設けたコネクタ 17 及び 18 をそれぞれ CCU 4 及びレーザ光源 7 に接続することができる。

【0012】上記電子内視鏡 2 の挿入部 11 は、その先端に硬質の先端部 19 が形成され、この先端部 19 に隣接して湾曲自在の湾曲部 21 が形成され、さらにこの湾

曲部21の後端に長尺の軟性部22が形成されている。上記湾曲部21は操作部12とに設けた湾曲ノブ23を操作することにより、湾曲できるようになっている。上記コンピュータ5は、キーボード24と接続されている。

【0013】図2は電子内視鏡2の先端部19の断面を示す。電子内視鏡2の先端部19には、被検査物を照明するための図示しないライトガイドファイバ、照明レンズ部、及び画像を得るための撮像ユニット26、物体面に干渉縞を投影する干渉縞投影ユニット27、物体面の干渉縞照明範囲内に輝点を作るためのレーザスポット投影ユニット28が設けられている。

【0014】前記撮像ユニット27は対物レンズ系29及び対物レンズ系29により結像した光学像を電気信号へ変換するための固体撮像素子30及び信号ケーブル31を有する。

【0015】前記干渉縞投影ユニット27は偏波面保存ファイバ32及び偏波面保存ファイバ32の射出光からx軸偏波成分の光とy軸偏波成分の光を分離する為の複屈折光学部材33及び、可干渉波であるx軸偏波とy軸偏波の45°成分を取り出す偏光板34及び、前記可干渉波を物体面に投影する投影レンズ35により構成される。

【0016】尚、図2に示すように複屈折光学部材33は、カバーガラス36、36で両面が保護されている。

又、偏波面保存ファイバ32の先端は口金37により、

$$I(x, y, n) = I_0(x, y) [1 + \gamma \cos \{2\pi\omega(x, y) + \phi_n\}] \quad (1)$$

となる。ここで、

$I_0(x, y)$: 光源の強度分布

γ : 可視度

$\omega(x, y)$: 物体光の歪

$$\phi_n = n\pi/2 \quad (n=0, 1, 2, 3) \quad (2)$$

とすると、

$$I(x, y, 1) = I_0(x, y) [1 + \gamma \cos 2\pi\omega(x, y)] \quad (3)$$

$$I(x, y, 2) = I_0(x, y) [1 - \gamma \sin 2\pi\omega(x, y)] \quad (4)$$

$$I(x, y, 3) = I_0(x, y) [1 - \gamma \cos 2\pi\omega(x, y)] \quad (5)$$

$$I(x, y, 4) = I_0(x, y) [1 + \gamma \sin 2\pi\omega(x, y)] \quad (6)$$

と表される。

【0022】(3) (4) (5) (6) 式より、

$$2\pi\omega(x, y) = \arctan [(I_4 - I_2) / (I_1 - I_3)] \quad (7)$$

となる。

【0023】ここで物体 $\omega(x, y)$ は光強度分布の位相ずれと解釈できるから、図4に示すように例えば対物レンズ系29の光軸上における被検体としての物体側に直

$$(2\pi/T') \Delta z \tan \theta = \arctan [(I_4 - I_2) / (I_1 - I_3)] \quad (8)$$

となる。

$$T' = L\lambda/d \cos \theta \quad (9)$$

λ : レーザの波長

d : x軸偏波光源p1とy軸偏波p2光源間の距離

パイプ38に固着され、このパイプ38は先端部19に固定される。先端部19の後端に湾曲部21を形成する第1の駒39が固着され、この駒39にはさらに次の駒39が回動自在に連結されるという具合にして多数の駒39、39…が回動自在に連結されている。多数の駒39、39…は可撓性のチューブ40で被覆されている。

【0017】前記レーザスポット投影ユニット28は光ファイバ41及び光ファイバ41からの出射光を所定の光束径へ変換する凸レンズ42、及び前記光束を所定の角度で出射するためのプリズム43を有する。上記光ファイバ41の先端は、口金44を介してパイプ45に固着され、このパイプ45は先端部19に固定される。

【0018】尚、撮像ユニット26もパイプ46を介して先端部19に固定されるようになっている。図3は、この電子内視鏡2によって、物体を計測している様子を示す。干渉縞投影ユニット27より干渉縞を物体面48の撮像範囲49内に投影する。この物体面48上に形成された干渉縞照射範囲を符号47で示す。また、前記干渉縞照射範囲47内の一点に、レーザスポット投影ユニット28よりレーザスポットを照射して輝点50をつくる。

【0019】図4、図5に示す原理図をもとに計測方法を説明する。干渉縞投影による形状測定は種々の方法が提案されているが、例えば4バケット法では以下の式により計算される。

【0020】干渉縞の強度分布 $I(x, y, n)$ は、

ϕ_n : 干渉光の初期位相である。

30 【0021】初期位相 ϕ_n を 90° づつ変化させ、

$I_n = I(x, y, n)$ で表すと

角座標の原点を設定し、干渉縞を投影する光源の位置、つまり光軸とx軸偏波光源p1とy軸偏波p2光源の中心点とのなす角を θ として、この解釈を当てはめると(7)式は、

【0024】ここで、

である。

50 【0025】よって物体における高さ Δz は、

$$\Delta z(x, y) = (T' / 2\pi \tan \theta) \cdot \arctan [(I4 - I2) / (I1 - I3)] \quad (10)$$

となる。ここで内視鏡先端から物体面までの距離Lをレーザスポット投影ユニット28を用いて測定する。

【0026】以降にレーザスポットによる測距方法を示す。図5に示すように物体面のレーザスポットによる輝点をP、対物レンズ系29の中心点をO、レーザスポッ

$$L = (H \cdot \sin \alpha \cdot \sin \beta) / \{\sin (\beta - \alpha)\} \quad (11)$$

この(11)式による測長結果を(9)式に代入すれば(10)式より物体表面の高さ Δz を求めることができる。干渉縞の範囲内の全ての $\Delta z(x, y)$ について同様に計算すれば物体表面3次元形状が得られる。

【0028】図6はレーザ光源のブロック図を示す。コネクタ18には干渉縞投影用コネクタ18a及びレーザスポット当投影用光コネクタ18bが設けられている。前記干渉縞投影用光コネクタ18aの図示しない偏波面保存光ファイバ端面にはコリメートレンズ51aにより半導体レーザ52aの光線が集光するように構成されている。前記半導体レーザ52aには支持板53、ペルチェ素子54を介してヒートシンク55aが取り付けられている。

【0029】また、前記支持板53には温度検出素子である例えばサーミスタ56が取り付けられている。前記ペルチェ素子54及びサーミスタ56は定温度制御回路57に接続されており、前記半導体レーザ52aを一定の温度に保つように温度制御される。

【0030】また、前記半導体レーザ52aは電流制御回路58に接続され、所定の電流値で駆動される。前記電流制御回路58はD/Aコンバータ回路59を通じてコンピュータ5の信号により任意の電流値へ設定される。

【0031】半導体レーザ52aは駆動電流を変化させると波長がシフトする。前記コンピュータ5により半導体レーザ52aの駆動電流を変化させると前記干渉縞投影ユニット27の干渉光の位相がシフトして、物体上の干渉縞を移動させることができる。

【0032】レーザスポット投影用光コネクタ18bの図示しない光ファイバ端面にはプリズム60、コリメートレンズ61bにより半導体レーザ62bの光線が集光するように構成されている。また、前記半導体レーザ62bは放熱のためにヒートシンク63bに取り付けられている。前記半導体レーザ62bは定電流制御回路64により定電流駆動される。

【0033】但し、レーザスポット投影用の光源としては、高輝度LED等の発光源を用いてもよい。次に第1実施例による測長方法を以下に説明する。内視鏡先端部19を被測定物である物体表面に対向させ測定範囲が干渉縞照射範囲内に入るようにセットする。

【0034】レーザスポット投影ユニット28からのレーザビームによる物体面上の輝度位置を撮像系を通じて

ト投影点をQとする。 x' 軸とO-Pのなす角度を β 、 x' 軸とQ-Pのなす角度を α 、O-Qの長さをHとすると距離Lは次式で示される。

【0027】

求め(11)式より距離Lを求める。次にコンピュータ5によりレーザ光源7へ信号を送り、干渉縞の位相を $\pi/4$ ずつ変化させ4枚の画像をCCU4内又はコンピュータ5内の図示しないフレームメモリへ取り込む。4枚の画像を(10)式を用いた演算をコンピュータ5で行うことにより、物体表面の3次元形状が得られる。

【0035】このように内視鏡的に測距と3次元計測が同時にできるシステムを提供することにより従来分解しなければ精密な計測が不可能であった、例えば曲面形状であるジェットエンジンのタービンブレードのクラック寸法を分解せずに精密に測定することができる。また、水道管等の減肉状態も非破壊的に精密測定できる。

【0036】また、レーザスポット投影用半導体レーザ62bと干渉縞投影用半導体レーザ52aに異なる波長のものを用いてもよい。たとえば、レーザスポット投影用半導体レーザとして青色レーザ、干渉縞投影用半導体レーザとして赤色レーザを用いれば、画像処理より青色レーザスポットにより測距を行い、赤色の干渉縞により3次元計測を自動的に行うことができる。

【0037】以下、図面を参照して本発明の第2実施例を具体的に説明する。

【0038】図7は、内視鏡先端部の断面図を示す。第2実施例は第1実施例に示したレーザビームによる測距方法を変更したものである。内視鏡先端部には先端面70に開口したチャンネル71を有し、前記チャンネル71からはゲージ72が先端方向に挿脱される。

【0039】前記ゲージ72には、測距用の目盛り73が記されており、視野のB点より前記目盛り73を読み取る。前記目盛り73はB点の値が内視鏡先端面70から物体面までの距離を表すようにあらかじめオフセットして記されている。読み取った値を距離Lとして第1実施例に示す(9)(10)(11)式を用いれば物体表面の3次元形状を求めることができる。

【0040】本実施例によれば測距用のレーザスポット投影ユニット及び光源が不要となるためより安価なシステムを提供できる。尚、測距方法は本実施例に限るものではなく、例えば、照明光と一緒に指標となる影等を投影し、それを基に測距するといったものでもよい。次に第3実施例を説明する。

【0041】第3実施例はレーザ光源ブロック内に1つのレーザ光源を用いたものである。図8はレーザ光源7のブロック図を示す。半導体レーザ80の出射光はコリ

メートルレンズ81により平行光線に変換された後、ビームスプリッタ82により光路83aと光路83bに分岐される。光路83aの光は集光レンズ84によりレーザスポット投影用光コネクタ端子85に集光される。光路83bの光はプリズム86をへて集光レンズ87により干涉縞投影用光コネクタ端子88に集光される。その他の構成及び作用は第1実施例に同じである。

【0042】前記半導体レーザ80には支持板53、ペルチェ素子54を介してヒートシンク55aが取り付けられている。また、前記支持板53には温度検出素子である例えばサーミスタ56が取り付けられている。前記ペルチェ素子54及びサーミスタ56は定温度制御回路57に接続されており前記半導体レーザ80を一定の温度に保つように温度制御される。

【0043】また、前記半導体レーザ80は電流制御回路58に接続され、所定の電流値で駆動される。前記電流制御回路58はD/Aコンバータ回路59を通じてコンピュータ5の信号により任意の電流値へ設定される。半導体レーザ80は駆動電流を変化させると波長がシフトする。

【0044】前記コンピュータ5により半導体レーザ80の駆動電流を変化させると前記干涉縞投影ユニットの干涉光の位相がシフトして、物体上の干涉縞を移動させることができる。しかし、同じ半導体レーザ80の光を用いているレーザスポットは波長がシフトしてもその影響は受けない。

【0045】また、図9(a)、(b)に示すように光路89cに可動ミラー90を設け、光路89a、光路89bを選択可能にしても良い。この第3実施例又はその変形例では一つの半導体レーザ80で干涉縞とレーザスポットの光源を構成したことにより、より安価なシステムを提供できる。次に第4実施例を説明する。

【0046】第4実施例は一本の光ファイバを用いて内視鏡先端部にレーザ光を導き、内視鏡先端部内で光路を2分割して、干涉縞照射光学系及びレーザスポット照射系の光源として用いるものである。

【0047】図10は内視鏡先端の各光学系の配置を示す。図11は図10のA-A断面を示す。図12はレーザ光源の内部を示す。図12に示すように、電流制御、温度制御された半導体レーザ92の射出光はコリメートレンズ93、集光レンズ94をへて光コネクタ端子95へ集光される。前記光コネクタ端子95から入射した光は、図11に示すように光ファイバ96を通じて内視鏡先端部へ伝達される。内視鏡先端部に伝達されたレーザ光はコリメートレンズ97により平行光線に変換された後ビームスプリッタ98により光路が2分割される。

【0048】前記ビームスプリッタ98を直進したレーザ光は光軸99aを経て干涉縞照射光学系101に入り、複屈折光学部材33、偏光板34、投影レンズ35等を経て物体表面に干涉縞が投影される。前記ビームス

プリッタ98により分岐したレーザ光は90°方向を変え、光路を経てレーザスポット照射光学系102に入り、プリズム103により内視鏡の軸方向に変換され、凸レンズ104、凹レンズ105によりビーム径が絞られた細径ビーム106にされた後にプリズム107により所定の角度で出射される。

【0049】図11において、偏波面を保存するファイバ96の先端は、口金108によりパイプ109に固着される。又、プリズム103等のレーザスポット照射光学系102はパイプ110に固着されている。図10において、対物レンズ系111の両側に、照明光学系112、112が設けてある。その他の構成は、第3実施例と同様である。

【0050】このように1本の光ファイバ96からの射出光を干涉縞照射及びレーザスポット照射用いたことにより高価な光ファイバ96の使用量が半減するため低価格な計測用内視鏡を提供できる。

【0051】次に本発明の第5実施例を具体的に説明する。図13ないし図18は本発明の第5実施例に係り、図13は内視鏡装置の全体構成の説明図、図14は内視鏡先端部の断面図、図15はレーザ光源のブロック図、図16はコンピュータのブロック図、図17はピエゾ素子の駆動電圧(DC-AMP出力電圧)と各フレームメモリのフリーズのタイミングを示すタイミングチャート図、図18は物体面に投影されている干涉縞の位相の変化を示す説明図である。

【0052】図13に示すように、本発明の第5実施例の計測用内視鏡装置201は計測用の電子内視鏡202と、この電子内視鏡202が接続される照明用光源203及びCCU204と、前記CCU204に接続されるコンピュータ205と、コンピュータ205からの画像を表示するモニタ206及びレーザ光源207を備えている。

【0053】上記電子内視鏡202は、細長の挿入部211と、この挿入部211の後端に連設された太幅の操作部212とを有し、この操作部212から外部に延出されたユニバーサルケーブル213の先端に設けられた光源コネクタ214を照明用光源203に着脱自在で装着することができる。このコネクタ214から信号ケーブル215と光ケーブル216とが延出され、それぞれの端部に設けたコネクタ217及び218をそれぞれCCU204及びレーザ光源207に接続することができる。

【0054】上記電子内視鏡202の挿入部211は、その先端に硬質の先端部219が形成され、この先端部219に隣接して湾曲自在の湾曲部221が形成され、さらにこの湾曲部221の後端に長尺の軟性部222が形成されている。上記湾曲部221は操作部212とに設けた湾曲ノブ223を操作することにより、湾曲できるようになっている。上記コンピュータ205は、キー

ボード224と接続されている。

【0055】図14は電子内視鏡202の先端部219の断面を示す。電子内視鏡202の先端部219には、被検査物を照明するための図示しないライトガイドファイバ、照明レンズ部、及び画像を得るための撮像ユニット226、物体面に干渉縞を投影する干渉縞投影ユニット227、物体面の干渉縞照明範囲内に輝点を作るためのレーザスポット投影ユニット228が設けられている。上記撮像ユニット226は対物レンズ系229及び対物レンズ系229により結像した光学像を電気信号へ変換するための固体撮像素子230及び信号ケーブル231を有する。

【0056】上記干渉縞投影ユニット227はシングルモードファイバ232及び口金233で先端が固定されたこのシングルモードファイバ232の射出光を平行光にするコリメートレンズ234と、この平行光から互いに直交する2つの偏波成分の光に分離して出力する偏光ビームスプリッタ235と、該偏光ビームスプリッタ235を経た光を投影する投影レンズ236と、前記一方の偏波成分の光を他方の偏波成分の光に対して光路差を与えるためのミラー237、238と、一方のミラー237を該ミラー237面に垂直な方向に変位させるためのピエゾ素子239とを有する。

【0057】上記投影レンズ236、ミラー238、ミラー237の裏面に形成された蒸着などで形成された反射面237aに取り付けられたピエゾ素子239はホルダ241を介して先端部219に取り付けられている。なお、ミラー238の裏面にも蒸着などで反射面238aが形成されている。上記2つのミラー237、238は偏光ビームスプリッタ235の上下両側に配置され、ミラー237は偏光ビームスプリッタ235と距離（例えばMとする）隔てて配置され、他方のミラー238は偏光ビームスプリッタ235の上面に接して配置され、例えばその厚さがNである。

【0058】上記ピエゾ素子239の両面には電極が取り付けられ、各電極にはリード線242の先端と接続され、図示しない駆動回路からピエゾ素子239を駆動して、ミラー237の位置を上下方向に変位させることができるようになっている。

【0059】上記コリメートレンズ234を経た平行光は偏光ビームスプリッタ235を透過して光路Aに沿って進む光成分と、偏光ビームスプリッタ235で反射され、第1のミラー237で反射され、偏光ビームスプリッタ235を透過し、第2のミラー238で反射され、さらに偏光ビームスプリッタ235で反射されて光路Bのように進む光成分とに分離され、光路Aに沿って進む光に対し、光路Bに沿って進む光は、偏光ビームスプリッタ235の上下方向の厚み（長さ）をLとすると、 $2(rL+sM+N)$ （r, sは偏光ビームスプリッタ235、ミラー238の屈折率）だけ大きい光路長（光路

差）Dが与えられた後、共に投影レンズ236を経て被写体（物体面）側に投影される。

【0060】そして被写体側には光路差Dに応じて図3で示したような干渉縞が形成されることになり、さらに上記ピエゾ素子239を駆動して、ミラー237の位置を上下方向に変位させることにより、この光路差Dから微小光路差 ΔD だけ変位させることができるようになっている。この微小光路差 ΔD だけ変位させることにより、干渉縞がシフトし、4バケット法で物体面の3次元形状を求めることができるようにしている。

【0061】上記レーザスポット投影ユニット228は光ファイバ244及び光ファイバ244からの出射光を所定の光束径へ変換する凸レンズ245、及び前記光束を所定の角度で出射するためのプリズム246を有する。上記光ファイバ244の先端は、口金247を介してパイプ248に固着され、このパイプ248は先端部219に固定される。

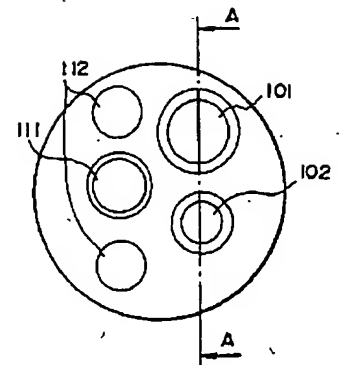
【0062】図15はレーザ光源207のブロック図を示す。半導体レーザ80の出射光はコリメートレンズ81により平行光線に変換された後、ビームスプリッタ82により光路83aと光路83bに分岐される。光路83aの光は集光レンズ84によりレーザスポット投影用光コネクタ端子85に集光される。又、半導体レーザ80は定電流制御回路258により駆動される。この定電流制御回路258はD/Aコンバータ回路59を通じてコンピュータ205によって制御され、干渉縞を適切な光量に保つ。その他の構成は図8に示す第3実施例のレーザ光源7と同じである。

【0063】一方、上記コンピュータ205の内部構成を図16に示す。上記CCU204からの画像信号はフレームメモリ部251を構成するフレームメモリA、B、C、Dに入力され、（CPU&メモリ252）のCPUからの信号により任意のタイミングでフリーズできる。又、内視鏡先端部219の干渉縞投影ユニット227に組み込まれたピエゾ素子239の変位はCPUによりD/Aコンバータ253、DC-AMP254を通じて電圧で制御される。

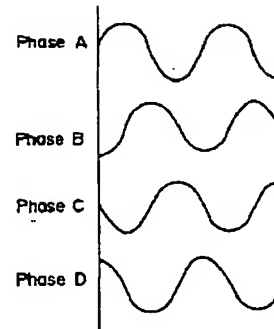
【0064】つまり、コンピュータ205からピエゾ素子239の変位を制御することにより、上記光路Aと光路Bの光路差Dから微小光路差 ΔD を変え、干渉縞の位相を任意に設定できる。そして、CPUによる演算結果はグラフィックボード255を通じてモニタ206に表示される。

【0065】上記ピエゾ素子239への駆動電圧とフレームメモリA、B、C、Dのフリーズのタイミングを図17に示す。この図17に示すように、ピエゾ素子239に印加されるDC-AMP254の出力電圧は階段状に変化させ、物体面に投影される干渉縞の位相（Phase）が 90° 毎に変化するように、つまり図18に示すようにPhase A、B、C、Dが 90° 毎に変化

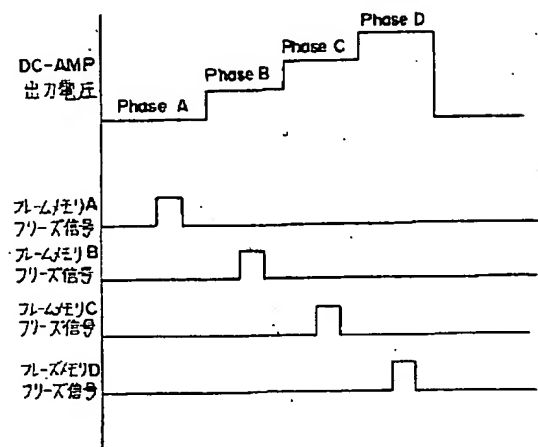
【図 10】



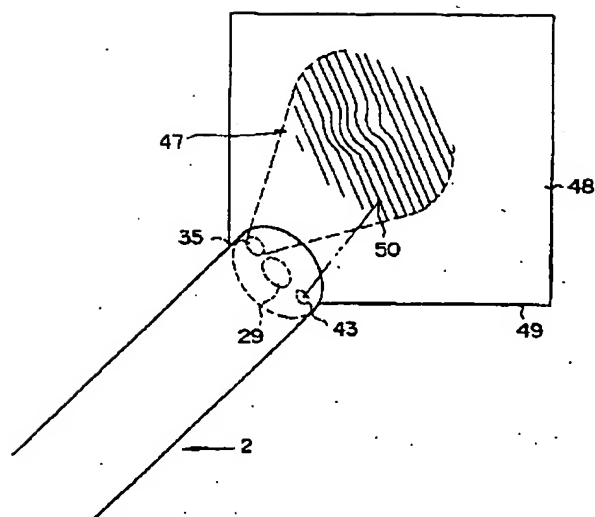
【図 18】



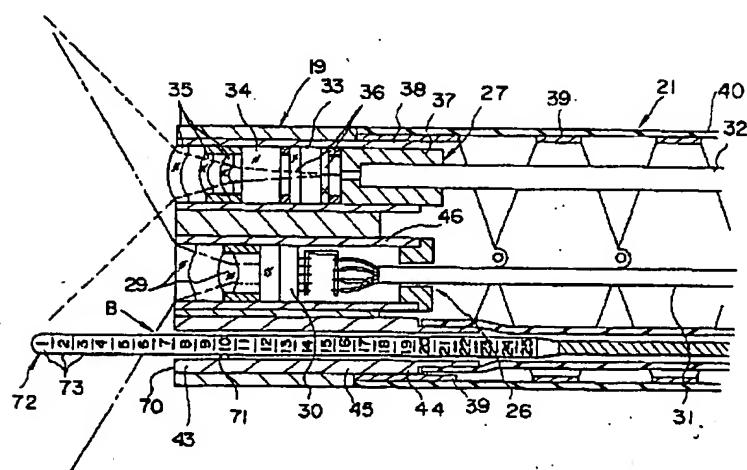
【图 17】



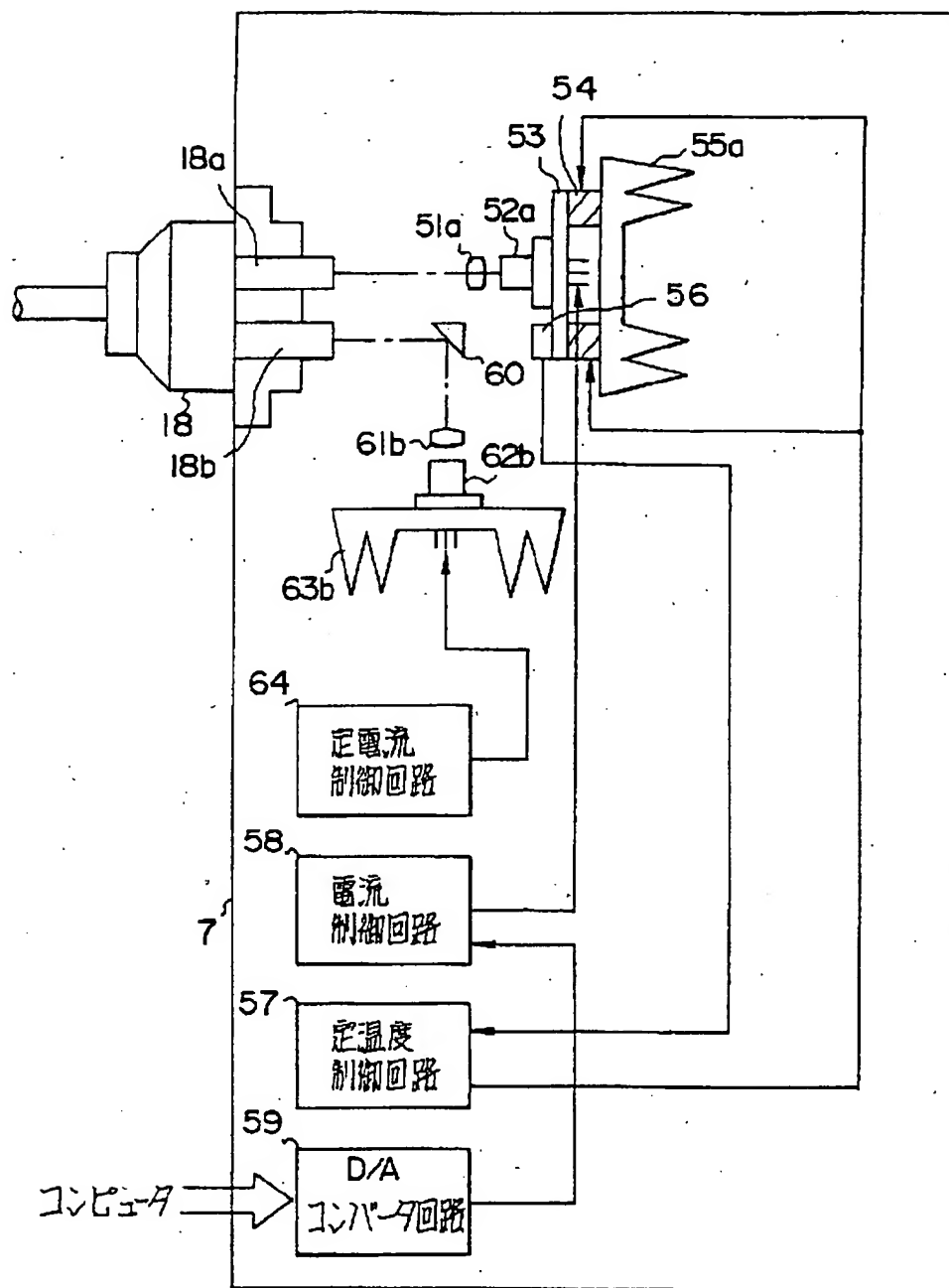
【図 3】



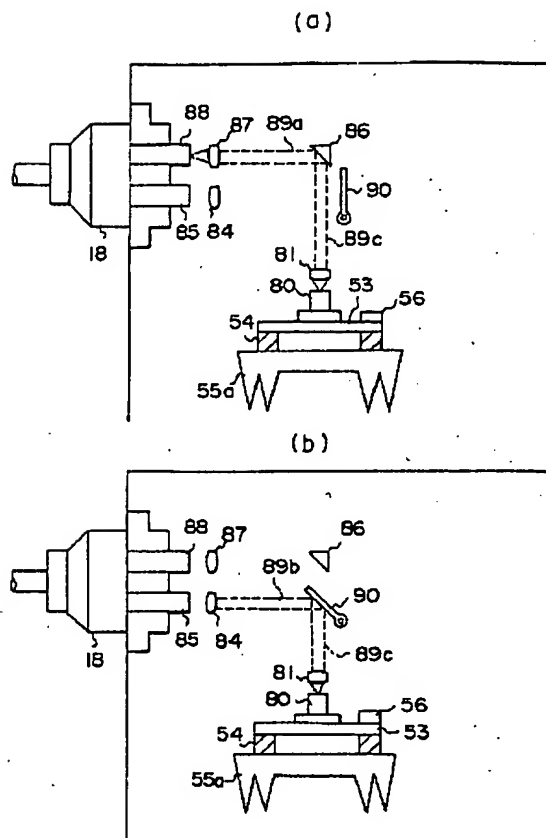
【図 7】



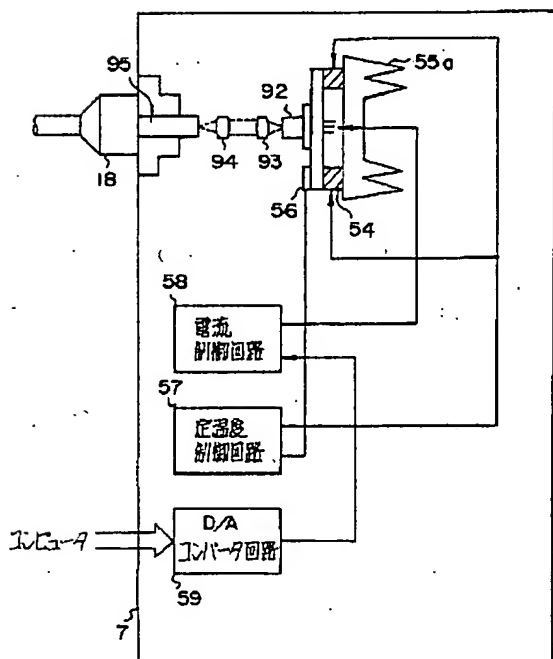
【図6】



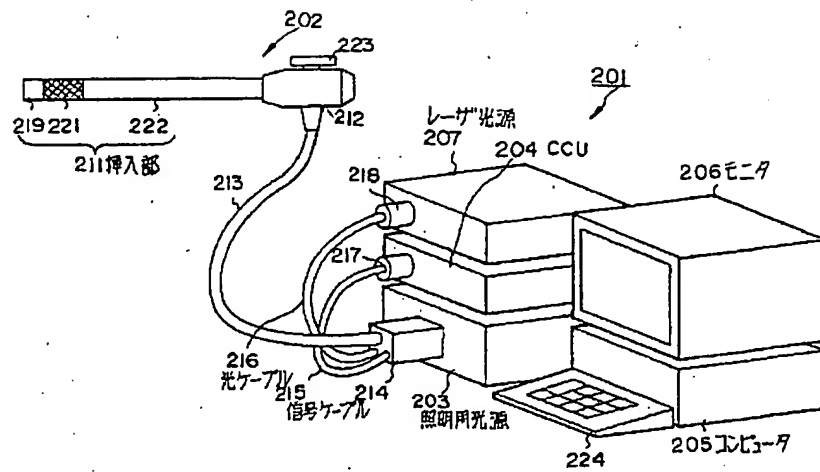
【図 9】



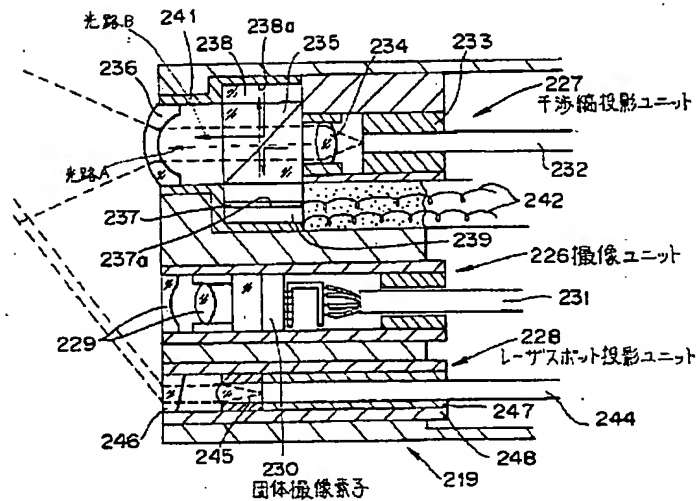
【例 12】



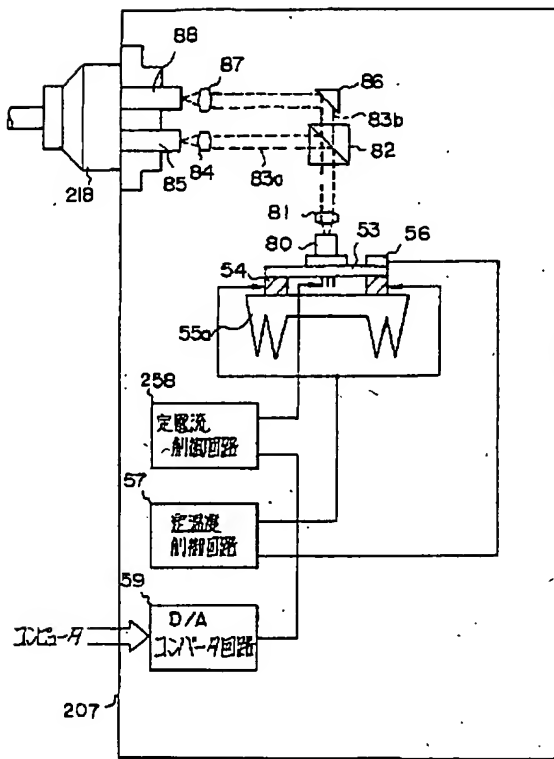
【図13】



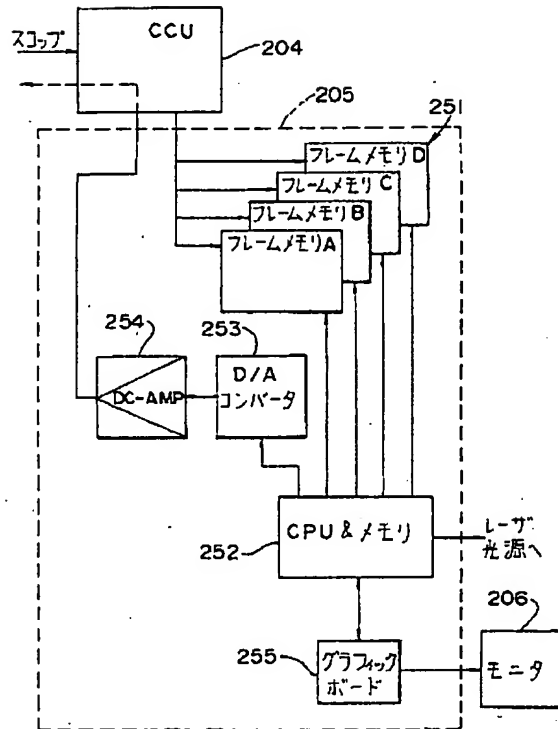
【図14】



【図 15】



【図 16】



フロントページの続き

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CLAIMS

[Claim(s)]

[Claim 1] Endoscope equipment for instrumentation characterized by providing an image pick-up means to picturize an analyte image, an interference fringe irradiation means to irradiate an interference fringe to the aforementioned analyte, a ranging means to measure the distance from the insertion section nose of cam of an endoscope to an analyte, and an operation means to calculate the 3-dimensional information on the aforementioned analyte based on the ranging information on the aforementioned ranging means.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] this invention relates to the endoscope equipment for instrumentation equipped with a ranging means to measure the distance from the nose of cam of an endoscope to an analyte.

[0002]

[Description of the Prior Art] By inserting the insertion section of ** length into a coelome in recent years, a coelome viscus machine etc. is observed or the endoscope to which various treatment treatment is made using the treatment implement inserted in in the treatment implement channel if needed is used widely. Moreover, also in the industrial field, the industrial-use endoscope is widely used for observation of the crack of the interior, such as a boiler, a turbine, an engine, and a chemical processing plant, the cauterization, etc., and the check.

[0003] A means to emit the beam light for length measurement to JP,59-69721,A at an endoscope point is shown. Moreover, the ranging means by one laser beam is shown in JP,62-73223,A. the thing using the diffraction pattern of a laser beam boiled and twisted in a diffraction grid as an instrumentation endoscope which measures the irregularity on the front face in the living body of internal organs etc. to JP,64-49542,A is shown

[0004] This diffraction pattern is projected on a device-under-test front face with a projection lens, and when this projection image is observed with image pick-up elements, such as a solid state image pickup device, from the position with parallax, according to the shape of a surface toothing, a line or a dot-like pattern deforms and it appears. Therefore, the shape of a toothing on the front face of a body is measurable by calculating the amount of displacement of the lightness from a criteria position about each bright section of the line-like pattern on a device-under-test front face based on the picture signal of an image pick-up element. Moreover, there is the technique of projecting an interference fringe on a body front face, scanning the aforementioned interference fringe, and raising the accuracy of measurement as a well-known fact.

[0005]

[Problem(s) to be Solved by the Invention] As for JP,64-49542,A, instrumentation precision is decided by the pitch of a dot-like pattern. Although a pitch must be made fine for raising precision, if a size, a pattern irradiation domain, etc. of a pattern projection optical system are taken into consideration, a limitation will be in pitch width of face, and highly precise instrumentation cannot be performed.

[0006] On the other hand, although about 1 / about 50 accuracy of measurement of the striped pitch of an interference fringe is obtained in the configuration measurement by the interference fringe scanning method, if a module (calibration by the fringe spacing on the object distance or a body side or known configuration measurement) is not inputted, the absolute value (actual size) of a 3-dimensional configuration cannot be obtained. However, generally, by the configuration measurement by the endoscope, since the instrumentation inside a machine serves as the main purposes, modules, such as the object distance, cannot be known beforehand and neither the input of the object distance nor a calibration can be

performed.

[0007] this invention is made in view of the above-mentioned situation, and does not need a complicated calibration, but it aims at offering the endoscope equipment for instrumentation which can search for a solid configuration often [precision] and quickly.

[0008]

[The means and operation] which solve a trouble An image pck-up means to picturize an analyte image in this invention, and an interference fringe irradiation means to irradiate an interference fringe to an analyte, By providing a ranging means to measure the distance from the insertion section nose of cam of an endoscope to an analyte, and an operation means to calculate the 3-dimensional information on an analyte based on the ranging information on this ranging means As the 3-dimensional information on an analyte is searched for by the operation by the aforementioned operation means based on the ranging information and interference fringe of a ranging means, a complicated calibration is not needed but a solid configuration can be searched for with a sufficient precision.

[0009]

[Example] Hereafter, with reference to a drawing, the example of this invention is explained concretely. The principle view [accord / the cross section of an endoscope point and the drawing 3] of instrumentation / the schematic diagram of 3-dimensional instrumentation / according / apply the drawing 1 or the drawing 6 to the 1st example of this invention, and / drawing / 1 / drawing 4 / to an interference fringe in explanatory drawing of the whole configuration of endoscope equipment and the drawing 2, the principle view of the ranging technique according / drawing 5 / to a laser spot, and the drawing 6 show the block diagram of a laser light source

[0010] As shown in drawing 1, the electronic endoscope 2 for instrumentation in the endoscope equipment for instrumentation 1 of the 1st example of this invention, The light source for a lighting 3 to which this electronic endoscope 2 is connected, and the camera control unit 4 (following CCU), It connects with aforementioned CCU4, and while the interference fringe for acquiring the monitor 6 and 3-dimensional information which display the picture image from the computer 5 by which an operation etc. carries out a 3-dimensional information, and the computer 5 is projected, it has the laser light source 7 which projects the luminescent spot for ranging.

[0011] It can detach [connector / light source / 14 / which was prepared at the nose of cam of the universal cable 13 which the above-mentioned electronic endoscope 2 has the insertion section 11 of ** length, and the control unit 12 of **** formed successively by the back end of this insertion section 11, and extended outside from this control unit 12] freely to the light source for a lighting 3, and can equip. A signal cable 15 and the optical cable 16 can extend from this connector 14, and the connectors 17 and 18 prepared in each edge can be connected to CCU4 and the laser light source 7, respectively.

[0012] The hard point 19 is formed at the nose of cam, the insertion section 11 of the above-mentioned electronic endoscope 2 adjoins this point 19, the bend 21 which can curve freely is formed, and the long elasticity section 22 is further formed in the back end of this bend 21. The above-mentioned bend 21 can curve now by operating the curve knob 23 prepared in the control unit 12. The above-mentioned computer 5 is connected with the keyboard 24.

[0013] Drawing 2 shows the cross section of the point 19 of the electronic endoscope 2. The laser spot projection unit 28 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pck-up unit 26 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 19 of the electronic endoscope 2, the interference fringe projection unit 27 which projects an interference fringe on a-body side, and a body side.

[0014] The aforementioned image pck-up unit 27 has the solid state image pickup device 30 and the signal cable 31 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 29 and the objective lens system 29.

[0015] The aforementioned interference fringe projection unit 27 is constituted by the polarizing plate 34 which takes out 45 degree component of x shaft polarization and y-axis

polarization which is the birefringence optical member 33 and good interference wave for separating the light of x shaft polarization component, and the light of a y-axis polarization component from the injection light of the plane-of-polarization store fiber 32 and the plane-of-polarization store fiber 32, and the projection lens 35 which projects the aforementioned good interference wave on a body side.

[0016] In addition, as shown in drawing 2, as for the birefringence optical member 33, both sides are protected with cover glass 36 and 36. Moreover, the nose of cam of the plane-of-polarization store fiber 32 fixes to a pipe 38 with a mouthpiece 37, and this pipe 38 is fixed to a point 19. 1st ** 39 which forms a bend 21 fixes, it is made the condition of connecting with this ** 39 still free [rotation of next ** 39], and much **s 39 and 39 — are connected with the back end of a point 19 free [rotation]. Much **s 39 and 39 — are covered with the flexible tube 40.

[0017] The aforementioned laser spot projection unit 28 has the prism 43 for carrying out the outgoing radiation of the convex lens 42 which changes the outgoing-radiation light from the optical fiber 41 and the optical fiber 41 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 41 fixes to a pipe 45 through a mouthpiece 44, and this pipe 45 is fixed to a point 19.

[0018] In addition, the image pck-up unit 26 is also fixed to a point 19 through a pipe 46. Drawing 3 shows a mode that the body is measured, with this electronic endoscope 2. An interference fringe is projected into the image pck-up domain 49 of the body side 48 from the interference fringe projection unit 27. A sign 47 shows the interference fringe irradiation domain formed on this body side 48. Moreover, to one in the aforementioned interference fringe irradiation domain 47, from the laser spot projection unit 28, a laser spot is irradiated and the luminescent spot 50 is built.

[0019] The instrumentation technique is explained on the basis of the principle view showing in drawing 4 and the drawing 5. The configuration measurement by interference fringe projection is calculated by the following formulas, for example by the 4 bucket method, although various technique is proposed.

[0020] Intensity-distribution $I(x, y, \text{ and } n)$ of an interference fringe is $I(x, y, \text{ and } n) = I_0 [(x \text{ and } y)1 + \gamma \cos(\pi \omega(x \text{ and } y) + \phi_n)]$ (1).

It becomes. Here, it is I_0 . (x and y) : Intensity-distribution γ of the light source : Visibility ω (x and y) : Distortion ϕ_n of body light : It is the initial phase of an interference light.

[0021] Initial-phase ϕ_n It changes 90 degrees at a time. $\phi_n = n\pi/2$ ($n = 0, 1, 2, 3$) (2)

When it carries out, it is. $I(x \text{ and } y1) = I_0 [(x \text{ and } y)1 + \gamma \cos 2\pi \omega(x \text{ and } y)]$ (3)

$I(x \text{ and } y2) = I_0 [(x \text{ and } y)1 - \gamma \sin 2\pi \omega(x \text{ and } y)]$ (4)

$I(x \text{ and } y3) = I_0 [(x \text{ and } y)1 - \gamma \cos 2\pi \omega(x \text{ and } y)]$ (5)

$I(x \text{ and } y4) = I_0 [(x \text{ and } y)1 + \gamma \sin 2\pi \omega(x \text{ and } y)]$ (6)

It is expressed.

[0022] If expressed with $I_n = I(x, y, \text{ and } n)$ from (3), (4), (5), and (6) formula $2\pi \omega(x \text{ and } y) = \arctan [(I4 - I2)/(I1 - I3)]$ (7)

It becomes.

[0023] Since body $\omega(x \text{ and } y)$ can be interpreted as the phase shift of optical intensity distribution, here As shown in drawing 4, the zero of rectangular coordinates is set to the body side as an analyte on the optical axis of the objective lens system 29. The position, i.e., an optical axis, x shaft polarization light source p1, and y-axis polarization p2, of the light source which projects an interference fringe They are (7) formulas if this interpretation is applied, using the angle with the middle point of the light source to make as theta. $(2\pi/T') \Delta z \tan \theta = \arctan [(I4 - I2)/(I1 - I3)]$ (8)

It becomes.

[0024] It is here. $T' = \lambda / d \cos \theta$ (9)

λ : Wavelength d of laser : x shaft polarization light source p1 and y-axis polarization p2 It is the distance between the light sources.

[0025] Therefore, height Δz in a body, $\Delta z(x \text{ and } y) = (T'/2 \tan \theta) - \arctan [(I4 - I2)/$

[I1-I3] (10)

It becomes. Distance L from an endoscope nose of cam to a body side is measured here using the laser spot projection unit 28.

[0026] The ranging technique by the laser spot is shown henceforth. As shown in drawing 5, O and the point projecting [laser spot] are set [the luminescent spot by the laser spot of a body side] to Q for the central point of P and the objective lens system 29. Distance L is shown by the following formula when the length of alpha and O-Q is set to H for the angle at which beta, and x' shaft and Q-P make the angle which x' shaft and O-P make.

[0027]

$$L = (H * \sin \alpha * \sin \beta) / \sin (\beta - \alpha) \quad (11)$$

If the length measurement result by this (11) formula is substituted for (9) formulas, height Δz on the front face of a body can be calculated from (10) formulas. If it calculates similarly about all Δz within the limits of an interference fringe (x and y), the 3-dimensional configuration of body surface will be acquired.

[0028] Drawing 6 shows the block diagram of a laser light source. Connector 18a for interference fringe projection and laser spot this optical connector 18b for projection are prepared in the connector 18. It is constituted by the plane-of-polarization store optical fiber end face which the aforementioned optical connector 18a for interference fringe projection does not illustrate so that the beam of light of semiconductor laser 52a may condense by collimate lens 51a. Heat sink 55a is attached in the aforementioned semiconductor laser 52a through the support plate 53 and the ***** element 54.

[0029] Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. It connects with the degree control circuit 57 of constant temperature, and the temperature control of the aforementioned ***** element 54 and the thermistor 56 is carried out so that the aforementioned semiconductor laser 52a may be maintained at fixed temperature.

[0030] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 52a is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59.

[0031] If semiconductor laser 52a changes a drive current, wavelength will shift it. If the drive current of semiconductor laser 52a is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit 27 can shift, and the interference fringe on a body can be moved.

[0032] It is constituted by the optical fiber end face which optical connector 18b for laser spot projection does not illustrate so that the beam of light of semiconductor laser 62b may condense by prism 60 and collimate lens 61b. Moreover, the aforementioned semiconductor laser 62b is attached in heat sink 63b for thermolysis. The constant-current drive of the aforementioned semiconductor laser 62b is carried out by the constant-current control circuit 64.

[0033] However, as light source for laser spot projection, you may use the sources of photogenesis, such as high brightness Light Emitting Diode. Next, the length measurement technique by the 1st example is explained below. It sets so that the endoscope point 19 may be made to counter the body front face which is a device under test and measuring range may go into interference fringe irradiation within the limits.

[0034] It asks for the brightness position on the body side by the laser beam from the laser spot projection unit 28 through an image pick-up system, and distance L is calculated from (11) formulas. Next, a signal is sent to a laser light source 7 by computer 5, and it incorporates to the frame memory to which the phase of an interference fringe is changed every [$4 / \pi$], and the picture image of four sheets is not illustrated in CCU4 or the computer 5. By performing the operation using (10) formulas of the picture image of four sheets by computer 5, the 3-dimensional configuration on the front face of a body is acquired.

[0035] Thus, if it did not decompose conventionally by offering the system which can perform

ranging and 3-dimensional instrumentation simultaneously in endoscope, precise instrumentation was impossible, for example, it can measure precisely, without decomposing the crack dimension of the turbine blade of the jet engine which is a curved-surface configuration. Moreover, **** status, such as a water pipe, can also be measured precisely in un-destroying.

[0036] Moreover, you may use the thing of the wavelength which is different in semiconductor laser 62b for laser spot projection, and semiconductor laser 52a for interference fringe projection. For example, if red laser is used as semiconductor laser for blue laser and interference fringe projection as semiconductor laser for laser spot projection, from an image processing, it can range by the blue laser spot and a red interference fringe can perform 3-dimensional instrumentation automatically.

[0037] Hereafter, with reference to a drawing, the 2nd example of this invention is explained concretely.

[0038] Drawing 7 shows the cross section of an endoscope point. The 2nd example changes the ranging technique by the laser beam shown in the 1st example. It has the channel 71 which carried out opening to the endoscope point at the apical surface 70, and inserts [gage / 72] in the orientation of a nose of cam from the aforementioned channel 71.

[0039] The graduation 73 for ranging is describing on the aforementioned gage 72, and the aforementioned graduation 73 is read from B points of a visual field. It may offset beforehand and the value of B points may be describing that the aforementioned graduation 73 expresses the distance from the endoscope apical surface 70 to a body side. If (9) which sets read value to distance L and is shown in 1st example, (10), and (11) formula is used, the 3-dimensional configuration on the front face of a body can be searched for.

[0040] Since the laser spot projection unit and the light source for ranging become unnecessary according to this example, a cheaper system can be offered. In addition, it is possible for the ranging technique not to restrict to this example, to project the shadow which serves as an index together with lighting light, and to range on the basis of it. Next, the 3rd example is explained.

[0041] The 3rd example uses one laser light source into a laser light source block. Drawing 8 shows the block diagram of a laser light source 7. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. The light of optical-path 83b is condensed by the condenser lens 87 through prism 86 by the optical connector terminal for interference fringe projection 88. Other configurations and operations are the same as that of the 1st example.

[0042] Heat sink 55a is attached in the aforementioned semiconductor laser 80 through the support plate 53 and the ***** element 54. Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. The temperature control of the aforementioned ***** element 54 and the thermistor 56 is carried out so that it may connect with the degree control circuit 57 of constant temperature and the aforementioned semiconductor laser 80 may be maintained at fixed temperature.

[0043] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 80 is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59. If semiconductor laser 80 changes a drive current, wavelength will shift it.

[0044] If the drive current of semiconductor laser 80 is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit can shift, and the interference fringe on a body can be moved. However, even if wavelength shifts the laser spot which uses the light of the same semiconductor laser 80, the influence does not receive.

[0045] Moreover, as shown in drawing 9 (a) and (b), the movable mirror 90 may be formed in optical-path 89c, and you may make selectable optical-path 89a and optical-path 89b. In this

3rd example or its modification, a cheaper system can be offered by having constituted the light source of an interference fringe and a laser spot from one semiconductor laser 80. Next, the 4th example is explained.

[0046] The 4th example leads a laser beam to an endoscope point using one optical fiber, within an endoscope point, divides an optical path into two and uses it as light source of interference fringe irradiation optical system and laser spot illuminating system.

[0047] Drawing 10 shows arrangement of each optical system at the nose of cam of an endoscope. Drawing 11 shows the A-A cross section of drawing 10. Drawing 12 shows the interior of a laser light source. As shown in drawing 12, a current control and the outgoing-radiation light of the semiconductor laser 92 by which the temperature control was carried out are condensed through a collimate lens 93 and the condenser lens 94 to the fiber-optic-connector terminal 95. The light which carried out incidence from the aforementioned fiber-optic-connector terminal 95 is transmitted to an endoscope point through an optical fiber 96, as shown in drawing 11. 2 ****s of optical paths are carried out by the back beam splitter 98 from which the laser beam transmitted to the endoscope point was changed into the parallel ray by the collimate lens 97.

[0048] The laser beam which went the aforementioned beam splitter 98 straight on goes into the interference fringe irradiation optical system 101 through optical-axis 99a, and an interference fringe is projected on a body front face through the birefringence optical member 33, the polarizing plate 34, the projection lens 35, etc. The laser beam which branched by the aforementioned beam splitter 98 changes the orientation of 90 degree, goes into the laser spot irradiation optical system 102 through an optical path, and is changed into the shaft orientations of an endoscope by prism 103, and after making it the diameter beam 106 of thin to which the beam diameter was extracted by the convex lens 104 and the concave lens 105, the outgoing radiation of it is carried out at an angle of predetermined by prism 107.

[0049] In drawing 11, the nose of cam of a fiber 96 where plane of polarization is saved fixes to a pipe 109 with a mouthpiece 108. Moreover, the laser spot irradiation optical system 102, such as prism 103, fixes to the pipe 110. In drawing 10, the lighting optical system 112, 112 is formed in the both sides of the objective lens system 111. Other configurations are the same as that of the 3rd example.

[0050] thus, the outgoing-radiation light from one optical fiber 96 — **** for interference fringe irradiation and laser spot irradiation — since the amount of the expensive optical fiber 96 used is halved by things, the low cost endoscope for instrumentation can be offered

[0051] Next, the 5th example of this invention is explained concretely. The timing-chart view in which applying the drawing 13 or the drawing 18 to the 5th example of this invention, and the block diagram of a laser light source and the drawing 16 showing the block diagram of a computer, and, as for the cross section of an endoscope point and the drawing 15, showing the driver voltage (DC-AMP output voltage) of a piezo-electric element and the timing of a frieze of each frame memory for explanatory drawing of the whole configuration of endoscope equipment and the drawing 14, as for drawing 17, and the drawing 18 are explanatory drawings showing change of

[0052] As shown in drawing 13, the endoscope equipment for instrumentation 201 of the 5th example of this invention is equipped with the monitor 206 and the laser light source 207 which display the picture image from the light source for a lighting 203 and CCU204 to which the electronic endoscope 202 and this electronic endoscope 202 for instrumentation are connected, the computer 205 connected to aforementioned CCU204, and the computer 205.

[0053] It can detach [connector / light source / 214 / which was prepared at the nose of cam of the universal cable 213 which the above-mentioned electronic endoscope 202 has the insertion section 211 of ** length, and the control unit 212 of **** formed successively by the back end of this insertion section 211, and extended outside from this control unit 212] freely to the light source for a lighting 203, and can equip. A signal cable 215 and the optical cable 216 can extend from this connector 214, and the connectors 217 and 218 prepared in each edge can be connected to CCU204 and the laser light source 207, respectively.

[0054] The hard point 219 is formed at the nose of cam, the insertion section 211 of the

above-mentioned electronic endoscope 202 adjoins this point 219, the bend 221 which can curve freely is formed, and the long elasticity section 222 is further formed in the back end of this bend 221. The above-mentioned bend 221 can curve now by operating the curve knob 223 prepared in the control unit 212. The above-mentioned computer 205 is connected with the keyboard 224.

[0055] Drawing 14 shows the cross section of the point 219 of the electronic endoscope 202. The laser spot projection unit 228 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pick-up unit 226 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 219 of the electronic endoscope 202, the interference fringe projection unit 227 which projects an interference fringe on a body side, and a body side. The above-mentioned image pick-up unit 226 has the solid state image pickup device 230 and the signal cable 231 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 229 and the objective lens system 229.

[0056] The collimate lens 234 with which the above-mentioned interference fringe projection unit 227 makes parallel light injection light of this single mode fiber 232 to which the nose of cam was fixed with the single mode fiber 232 and the mouthpiece 233, The polarization beam splitter 235 separated and outputted to the light of two polarization components which intersect perpendicularly mutually from this parallel light, The projection lens 236 which projects the light which passed through this polarization beam splitter 235. It has the piezo-electric element 239 for making the variation rate of the mirrors 237 and 238 for giving the optical path difference for the light of aforementioned one polarization component to the light of the polarization component of another side, and one mirror 237 carry out in the orientation perpendicular [237th page of this mirror].

[0057] The piezo-electric element 239 attached in reflector 237a formed by the vacuum evaporationno formed in the rear face of the above-mentioned projection lens 236, the mirror 238, and the mirror 237 is attached in the point 219 through the electrode holder 241. In addition, reflector 238a is formed also in the rear face of a mirror 238 by vacuum evaporationno etc. The two above-mentioned mirrors 237 and 238 are arranged at the vertical both sides of a polarization beam splitter 235, a mirror 237 is distance(for example, referred to as M)-separated from a polarization beam splitter 235, and is arranged, and the mirror 238 of another side is arranged in contact with the top of a polarization beam splitter 235, for example, the thickness is N.

[0058] An electrode is attached in both sides of the above-mentioned piezo-electric element 239, to each electrode, it connects with the nose of cam of lead wire 242, a piezo-electric element 239 is driven from the drive circuit not to illustrate, and the variation rate of the position of a mirror 237 is carried out in the vertical orientation.

[0059] The optical component which the parallel light which passed through the above-mentioned collimate lens 234 penetrates a polarization beam splitter 235, and progresses along with optical-path A, It is reflected by the polarization beam splitter 235, and is reflected by the 1st mirror 237. Penetrate a polarization beam splitter 235 and it is reflected by the 2nd mirror 238. The light which progresses along with optical-path B to the light which is divided into the optical component which is furthermore reflected by the polarization beam splitter 235, and progresses like optical-path B, and progresses along with optical-path A If thickness (length) of the vertical orientation of a polarization beam splitter 235 is set to L After giving optical-path-length (optical path difference) D only with 2 [large] ($rL+sM+N$) (r and s are the refractive index of a polarization beam splitter 235 and the mirror 238), it is projected on a photographic subject (body side) side through both the projection lenses 236.

[0060] And an interference fringe which was shown in drawing 3 according to optical-path-difference D will be formed in a photographic subject side, the above-mentioned piezo-electric element 239 is driven further, and the variation rate only of the minute optical-path-difference delta D is carried out from this optical-path-difference D by making the variation rate of the position of a mirror 237 carry out in the vertical orientation. An interference fringe shifts and it enables it to search for the 3-dimensional configuration of a body side by the 4

bucket method by carrying out the variation rate only of this minute optical-path-difference ΔD .

[0061] The above-mentioned laser spot projection unit 228 has the prism 246 for carrying out the outgoing radiation of the convex lens 245 which changes the outgoing-radiation light from the optical fiber 244 and the optical fiber 244 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 244 fixes to a pipe 248 through a mouthpiece 247, and this pipe 248 is fixed to a point 219.

[0062] Drawing 15 shows the block diagram of a laser light source 207. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. Moreover, semiconductor laser 80 is driven by the constant-current control circuit 258. This constant-current control circuit 258 is controlled by the computer 205 through the D/A-converter circuit 59, and maintains an interference fringe at the suitable quantity of light. Other configurations are the same as that of the laser light source 7 of the 3rd example shown in drawing 8.

[0063] On the other hand, the internal configuration of the above-mentioned computer 205 is shown in drawing 16. The picture signal from above-mentioned CCU204 is inputted into the frame memories A, B, C, and D which constitute the frame memory section 251, and can be frozen to arbitrary timing with the signal from CPU of (the CPU & memory 252). Moreover, the variation rate of the piezo-electric element 239 included in the interference fringe projection unit 227 of the endoscope point 219 is controlled by the voltage by CPU through D/A converter 253 and DC-AMP254.

[0064] That is, by controlling the variation rate of a piezo-electric element 239 from a computer 205, optical-path-difference D to minute optical-path-difference ΔD of the above-mentioned optical-path A and optical-path B is changed, and the phase of an interference fringe can be set up arbitrarily. And the result of an operation by CPU is displayed on a monitor 206 through the graphic board 255.

[0065] The driver voltage to the above-mentioned piezo-electric element 239 and the timing of a frieze of frame memories A, B, C, and D are shown in drawing 17. The output voltage of DC-AMP254 impressed to a piezo-electric element 239 as shown in this drawing 17 is Phase, as it is shown in drawing 18 so that it may be made to change stair-like and the phase (Phase) of the interference fringe projected on a body side may change every 90 degrees that is, A, B, C, and D determine that the output voltage of DC-AMP254 will change every 90 degrees.

[0066] Moreover, it is made to generate the frieze signal which memorizes a frieze picture image to frame memories A, B, C, and D, respectively as shown in drawing 16 where the Gentlemen phase of the interference fringe projected on a body side is stabilized. Thus, the driver voltage to a piezo-electric element 239 is changed in the shape of a phase, the phase of the interference fringe on a body side is changed every 90 degrees, the picture image for every Gentlemen phase is incorporated to the four sheet frame memories A, B, C, and D, and a solid configuration is searched for by performing data processing by CPU. This operation technique is the same as that of the 1st example. In addition, you may use actuators, such as SMA, instead of the piezo-electric element 239 of this example.

[0067]

[Effect of the Invention] An interference fringe irradiation means and a spot beam-of-light irradiation means are prepared in an endoscope point, while an interference fringe is projected on a body side, a spot beam of light can be irradiated, at least one luminescent spot can be made to interference fringe irradiation within the limits, the distance from an endoscope nose of cam to [from the position of the aforementioned luminescent spot] a body side can be found, and the absolute value of a 3-dimensional configuration can be calculated by using the aforementioned distance in the operation of the 3-dimensional measurement by interference fringe projection.

[Translation done.]

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Field

[Field of the Invention] this invention relates to the endoscope equipment for instrumentation equipped with a ranging means to measure the distance from the nose of cam of an endoscope to an analyte.

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Technique

[Description of the Prior Art] By inserting the insertion section of ** length into a coelome in recent years, a coelome viscus machine etc. is observed or the endoscope to which various treatment treatment is made using the treatment implement inserted in in the treatment implement channel if needed is used widely. Moreover, also in the industrial field, the industrial-use endoscope is widely used for observation of the crack of the interior, such as a boiler, a turbine, an engine, and a chemical processing plant, the cauterization, etc., and the check.

[0003] A means to emit the beam light for length measurement to JP,59-69721,A at an endoscope point is shown. Moreover, the ranging means by one laser beam is shown in JP,62-73223,A. the thing using the diffraction pattern of a laser beam boiled and twisted in a diffraction grid as an instrumentation endoscope which measures the irregularity on the front face in the living body of internal organs etc. to JP,64-49542,A is shown

[0004] This diffraction pattern is projected on a device-under-test front face with a projection lens, and when this projection image is observed with image pck-up elements, such as a solid state image pickup device, from the position with parallax, according to the shape of a surface tothing, a line or a dot-like pattern deforms and it appears. Therefore, the shape of a tothing on the front face of a body is measurable by calculating the amount of displacement of the lightness from a criteria position about each bright section of the line-like pattern on a device-under-test front face based on the picture signal of an image pck-up element. Moreover, there is the technique of projecting an interference fringe on a body front face, scanning the aforementioned interference fringe, and raising the accuracy of measurement as a well-known fact.

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Effect

[Effect of the Invention] An interference fringe irradiation means and a spot beam-of-light irradiation means are prepared in an endoscope point, while an interference fringe is projected on a body side, a spot beam of light can be irradiated, at least one luminescent spot can be made to interference fringe irradiation within the limits, the distance from an endoscope nose of cam to [from the position of the aforementioned luminescent spot] a body side can be found, and the absolute value of a 3-dimensional configuration can be calculated by using the aforementioned distance in the operation of the 3-dimensional measurement by interference fringe projection.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As for JP,64-49542,A, instrumentation precision is decided by the pitch of a dot-like pattern. Although a pitch must be made fine for raising precision, if a size, a pattern irradiation domain, etc. of a pattern projection optical system are taken into consideration, a limitation will be in pitch width of face, and highly precise instrumentation cannot be performed.

[0006] On the other hand, although about 1 / about 50 accuracy of measurement of the striped pitch of an interference fringe is obtained in the configuration measurement by the interference fringe scanning method, if a module (calibration by the fringe spacing on the object distance or a body side or known configuration measurement) is not inputted, the absolute value (actual size) of a 3-dimensional configuration cannot be obtained. However, generally, by the configuration measurement by the endoscope, since the instrumentation inside a machine serves as the main purposes, modules, such as the object distance, cannot be known beforehand and neither the input of the object distance nor a calibration can be performed.

[0007] this invention is made in view of the above-mentioned situation, and does not need a complicated calibration, but it aims at offering the endoscope equipment for instrumentation which can search for a solid configuration often [precision] and quickly.

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OPERATION

[The means and operation] which solve a trouble An image pick-up means to picturize an analyte image in this invention, and an interference fringe irradiation means to irradiate an interference fringe to an analyte, By providing a ranging means to measure the distance from the insertion section nose of cam of an endoscope to an analyte, and an operation means to calculate the 3-dimensional information on an analyte based on the ranging information on this ranging means As the 3-dimensional information on an analyte is searched for by the operation by the aforementioned operation means based on the ranging information and interference fringe of a ranging means, a complicated calibration is not needed but a solid configuration can be searched for with a sufficient precision.

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EXAMPLE

[Example] Hereafter, with reference to a drawing, the example of this invention is explained concretely. The principle view [accord / the cross section of an endoscope point and the drawing 3] of instrumentation / the schematic diagram of 3-dimensional instrumentation / according / apply the drawing 1 or the drawing 6 to the 1st example of this invention, and / drawing / 1 / drawing 4 / to an interference fringe in explanatory drawing of the whole configuration of endoscope equipment and the drawing 2, the principle view of the ranging technique according / drawing 5 / to a laser spot, and the drawing 6 show the block diagram of a laser light source

[0010] As shown in drawing 1, the electronic endoscope 2 for instrumentation in the endoscope equipment for instrumentation 1 of the 1st example of this invention, The light source for a lighting 3 to which this electronic endoscope 2 is connected, and the camera control unit 4 (following CCU), It connects with aforementioned CCU4, and while the interference fringe for acquiring the monitor 6 and 3-dimensional information which display the picture image from the computer 5 by which an operation etc. carries out a 3-dimensional information, and the computer 5 is projected, it has the laser light source 7 which projects the luminescent spot for ranging.

[0011] It can detach [connector / light source / 14 / which was prepared at the nose of cam of the universal cable 13 which the above-mentioned electronic endoscope 2 has the insertion section 11 of ** length, and the control unit 12 of **** formed successively by the back end of this insertion section 11, and extended outside from this control unit 12] freely to the light source for a lighting 3, and can equip. A signal cable 15 and the optical cable 16 can extend from this connector 14, and the connectors 17 and 18 prepared in each edge can be connected to CCU4 and the laser light source 7, respectively.

[0012] The hard point 19 is formed at the nose of cam, the insertion section 11 of the above-mentioned electronic endoscope 2 adjoins this point 19, the bend 21 which can curve freely is formed, and the long elasticity section 22 is further formed in the back end of this bend 21. The above-mentioned bend 21 can curve now by operating the curve knob 23 prepared in the control unit 12. The above-mentioned computer 5 is connected with the keyboard 24.

[0013] Drawing 2 shows the cross section of the point 19 of the electronic endoscope 2. The laser spot projection unit 28 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pick-up unit 26 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 19 of the electronic endoscope 2, the interference fringe projection unit 27 which projects an interference fringe on a body side, and a body side.

[0014] The aforementioned image pick-up unit 27 has the solid state image pickup device 30 and the signal cable 31 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 29 and the objective lens system 29.

[0015] The aforementioned interference fringe projection unit 27 is constituted by the polarizing plate 34 which takes out 45 degree component of x shaft polarization and y-axis polarization which is the birefringence optical member 33 and good interference wave for separating the light of x shaft polarization component, and the light of a y-axis polarization component from the injection light of the plane-of-polarization store fiber 32 and the plane-

of-polarization store fiber 32, and the projection lens 35 which projects the aforementioned good interference wave on a body side.

[0016] In addition, as shown in drawing 2, as for the birefringence optical member 33, both sides are protected with cover glass 36 and 36. Moreover, the nose of cam of the plane-of-polarization store fiber 32 fixes to a pipe 38 with a mouthpiece 37, and this pipe 38 is fixed to a point 19. 1st ** 39 which forms a bend 21 fixes, it is made the condition of connecting with this ** 39 still free [rotation of next ** 39], and much **s 39 and 39 — are connected with the back end of a point 19 free [rotation]. Much **s 39 and 39 — are covered with the flexible tube 40.

[0017] The aforementioned laser spot projection unit 28 has the prism 43 for carrying out the outgoing radiation of the convex lens 42 which changes the outgoing-radiation light from the optical fiber 41 and the optical fiber 41 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 41 fixes to a pipe 45 through a mouthpiece 44, and this pipe 45 is fixed to a point 19.

[0018] In addition, the image pick-up unit 26 is also fixed to a point 19 through a pipe 46. Drawing 3 shows a mode that the body is measured, with this electronic endoscope 2. An interference fringe is projected into the image pick-up domain 49 of the body side 48 from the interference fringe projection unit 27. A sign 47 shows the interference fringe irradiation domain formed on this body side 48. Moreover, to one in the aforementioned interference fringe irradiation domain 47, from the laser spot projection unit 28, a laser spot is irradiated and the luminescent spot 50 is built.

[0019] The instrumentation technique is explained on the basis of the principle view showing in drawing 4 and the drawing 5. The configuration measurement by interference fringe projection is calculated by the following formulas, for example by the 4 bucket method, although various technique is proposed.

[0020] Intensity-distribution $I(x, y, \text{ and } n)$ of an interference fringe is $I(x, y, \text{ and } n) = I_0 [(x \text{ and } y)1 + \gamma \cos\{\omega(x \text{ and } y) + \phi_n\}]$ (1).

It becomes. Here, it is I_0 . (x and y) : Intensity-distribution γ of the light source : Visibility ω (x and y) : Distortion ϕ_n of body light : It is the initial phase of an interference light.

[0021] Initial-phase ϕ_n It changes 90 degrees at a time. $\phi_n = n\pi/2$ ($n = 0, 1, 2, 3$) (2)

When it carries out, it is. $I(x \text{ and } y1) = I_0 [(x \text{ and } y)1 + \gamma \cos 2\omega(x \text{ and } y)]$ (3)

$I(x \text{ and } y2) = I_0 [(x \text{ and } y)1 - \gamma \sin 2\omega(x \text{ and } y)]$ (4)

$I(x \text{ and } y3) = I_0 [(x \text{ and } y)1 - \gamma \cos 2\omega(x \text{ and } y)]$ (5)

$I(x \text{ and } y4) = I_0 [(x \text{ and } y)1 + \gamma \sin 2\omega(x \text{ and } y)]$ (6)

It is expressed.

[0022] If expressed with $I_n = I(x, y, \text{ and } n)$ from (3), (4), (5), and (6) formula $2\omega(x \text{ and } y) = \arctan [(I4 - I2)/(I1 - I3)]$ (7)

It becomes.

[0023] Since body $\omega(x \text{ and } y)$ can be interpreted as the phase shift of optical intensity distribution, here As shown in drawing 4, the zero of rectangular coordinates is set to the body side as an analyte on the optical axis of the objective lens system 29. The position, i.e., an-optical axis, x shaft polarization light source p1, and y-axis polarization p2, of the light source which projects an interference fringe They are (7) formulas if this interpretation is applied, using the angle with the middle point of the light source to make as theta. $(2\pi/T') \Delta z \tanh \theta = \arctan [(I4 - I2)/(I1 - I3)]$ (8)

It becomes.

[0024] It is here. $T' = L\lambda/d \cosh \theta$ (9)

λ : Wavelength d of laser : x shaft polarization light source p1 and y-axis polarization p2 It is the distance between the light sources.

[0025] Therefore, height Δz in a body, $\Delta z(x \text{ and } y) = (T'/2\pi \tanh \theta) - \arctan [(I4 - I2)/(I1 - I3)]$ (10)

It becomes. Distance L from an endoscope nose of cam to a body side is measured here using the laser spot projection unit 28.

[0026] The ranging technique by the laser spot is shown henceforth. As shown in drawing 5, O and the point projecting [laser spot] are set [the luminescent spot by the laser spot of a body side] to Q for the central point of P and the objective lens system 29. Distance L is shown by the following formula when the length of alpha and O-Q is set to H for the angle at which beta, and x' shaft and Q-P make the angle which x' shaft and O-P make.

[0027]

$$L = (H * \sin \alpha * \sin \beta) / \{\sin (\beta - \alpha)\} \quad (11)$$

If the length measurement result by this (11) formula is substituted for (9) formulas, height Δz on the front face of a body can be calculated from (10) formulas. If it calculates similarly about all Δz within the limits of an interference fringe (x and y), the 3-dimensional configuration of body surface will be acquired.

[0028] Drawing 6 shows the block diagram of a laser light source. Connector 18a for interference fringe projection and laser spot this optical connector 18b for projection are prepared in the connector 18. It is constituted by the plane-of-polarization store optical fiber end face which the aforementioned optical connector 18a for interference fringe projection does not illustrate so that the beam of light of semiconductor laser 52a may condense by collimate lens 51a. Heat sink 55a is attached in the aforementioned semiconductor laser 52a through the support plate 53 and the ***** element 54.

[0029] Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. It connects with the degree control circuit 57 of constant temperature, and the temperature control of the aforementioned ***** element 54 and the thermistor 56 is carried out so that the aforementioned semiconductor laser 52a may be maintained at fixed temperature.

[0030] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 52a is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59.

[0031] If semiconductor laser 52a changes a drive current, wavelength will shift it. If the drive current of semiconductor laser 52a is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit 27 can shift, and the interference fringe on a body can be moved.

[0032] It is constituted by the optical fiber end face which optical connector 18b for laser spot projection does not illustrate so that the beam of light of semiconductor laser 62b may condense by prism 60 and collimate lens 61b. Moreover, the aforementioned semiconductor laser 62b is attached in heat sink 63b for thermolysis. The constant-current drive of the aforementioned semiconductor laser 62b is carried out by the constant-current control circuit 64.

[0033] However, as light source for laser spot projection, you may use the sources of photogenesis, such as high brightness Light Emitting Diode. Next, the length measurement technique by the 1st example is explained below. It sets so that the endoscope point 19 may be made to counter the body front face which is a device under test and measuring range may go into interference fringe irradiation within the limits.

[0034] It asks for the brightness position on the body side by the laser beam from the laser spot projection unit 28 through an image pick-up system, and distance L is calculated from (11) formulas. Next, a signal is sent to a laser light source 7 by computer 5, and it incorporates to the frame memory to which the phase of an interference fringe is changed every $[4 / \pi]$, and the picture image of four sheets is not illustrated in CCU4 or the computer 5. By performing the operation using (10) formulas of the picture image of four sheets by computer 5, the 3-dimensional configuration on the front face of a body is acquired.

[0035] Thus, if it did not decompose conventionally by offering the system which can perform ranging and 3-dimensional instrumentation simultaneously in endoscope, precise instrumentation was impossible, for example, it can measure precisely, without decomposing the crack dimension of the turbine blade of the jet engine which is a curved-surface

configuration. Moreover, **** status, such as a water pipe, can also be measured precisely in un-destroying.

[0036] Moreover, you may use the thing of the wavelength which is different in semiconductor laser 62b for laser spot projection, and semiconductor laser 52a for interference fringe projection. For example, if red laser is used as semiconductor laser for blue laser and interference fringe projection as semiconductor laser for laser spot projection, from an image processing, it can range by the blue laser spot and a red interference fringe can perform 3-dimensional instrumentation automatically.

[0037] Hereafter, with reference to a drawing, the 2nd example of this invention is explained concretely.

[0038] Drawing 7 shows the cross section of an endoscope point. The 2nd example changes the ranging technique by the laser beam shown in the 1st example. It has the channel 71 which carried out opening to the endoscope point at the apical surface 70, and inserts [gage / 72] in the orientation of a nose of cam from the aforementioned channel 71.

[0039] The graduation 73 for ranging is describing on the aforementioned gage 72, and the aforementioned graduation 73 is read from B points of a visual field. It may offset beforehand and the value of B points may be describing that the aforementioned graduation 73 expresses the distance from the endoscope apical surface 70 to a body side. If (9) which sets read value to distance L and is shown in 1st example, (10), and (11) formula is used, the 3-dimensional configuration on the front face of a body can be searched for.

[0040] Since the laser spot projection unit and the light source for ranging become unnecessary according to this example, a cheaper system can be offered. In addition, it is possible for the ranging technique not to restrict to this example, to project the shadow which serves as an index together with lighting light, and to range on the basis of it. Next, the 3rd example is explained.

[0041] The 3rd example uses one laser light source into a laser light source block. Drawing 8 shows the block diagram of a laser light source 7. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. The light of optical-path 83b is condensed by the condenser lens 87 through prism 86 by the optical connector terminal for interference fringe projection 88. Other configurations and operations are the same as that of the 1st example.

[0042] Heat sink 55a is attached in the aforementioned semiconductor laser 80 through the support plate 53 and the ***** element 54. Moreover, the thermistor 56 which is a temperature sensing element is attached in the aforementioned support plate 53. The temperature control of the aforementioned ***** element 54 and the thermistor 56 is carried out so that it may connect with the degree control circuit 57 of constant temperature and the aforementioned semiconductor laser 80 may be maintained at fixed temperature.

[0043] Moreover, it connects with the current control circuit 58, and the aforementioned semiconductor laser 80 is driven with a predetermined current value. The aforementioned current control circuit 58 is set to arbitrary current values by the signal of a computer 5 through the D/A-converter circuit 59. If semiconductor laser 80 changes a drive current, wavelength will shift it.

[0044] If the drive current of semiconductor laser 80 is changed by aforementioned computer 5, the phase of the interference light of the aforementioned interference fringe projection unit can shift, and the interference fringe on a body can be moved. However, even if wavelength shifts the laser spot which uses the light of the same semiconductor laser 80, the influence does not receive.

[0045] Moreover, as shown in drawing 9 (a) and (b), the movable mirror 90 may be formed in optical-path 89c, and you may make selectable optical-path 89a and optical-path 89b. In this 3rd example or its modification, a cheaper system can be offered by having constituted the light source of an interference fringe and a laser spot from one semiconductor laser 80. Next, the 4th example is explained.

[0046] The 4th example leads a laser beam to an endoscope point using one optical fiber, within an endoscope point, divides an optical path into two and uses it as light source of interference fringe irradiation optical system and laser spot illuminating system.

[0047] Drawing 10 shows arrangement of each optical system at the nose of cam of an endoscope. Drawing 11 shows the A-A cross section of drawing 10. Drawing 12 shows the interior of a laser light source. As shown in drawing 12, a current control and the outgoing-radiation light of the semiconductor laser 92 by which the temperature control was carried out are condensed through a collimate lens 93 and the condenser lens 94 to the fiber-optic-connector terminal 95. The light which carried out incidence from the aforementioned fiber-optic-connector terminal 95 is transmitted to an endoscope point through an optical fiber 96, as shown in drawing 11. 2 ****s of optical paths are carried out by the back beam splitter 98 from which the laser beam transmitted to the endoscope point was changed into the parallel ray by the collimate lens 97.

[0048] The laser beam which went the aforementioned beam splitter 98 straight on goes into the interference fringe irradiation optical system 101 through optical-axis 99a, and an interference fringe is projected on a body front face through the birefringence optical member 33, the polarizing plate 34, the projection lens 35, etc. The laser beam which branched by the aforementioned beam splitter 98 changes the orientation of 90 degree, goes into the laser spot irradiation optical system 102 through an optical path, and is changed into the shaft orientations of an endoscope by prism 103, and after making it the diameter beam 106 of thin to which the beam diameter was extracted by the convex lens 104 and the concave lens 105, the outgoing radiation of it is carried out at an angle of predetermined by prism 107.

[0049] In drawing 11, the nose of cam of a fiber 96 where plane of polarization is saved fixes to a pipe 109 with a mouthpiece 108. Moreover, the laser spot irradiation optical system 102, such as prism 103, fixes to the pipe 110. In drawing 10, the lighting optical system 112, 112 is formed in the both sides of the objective lens system 111. Other configurations are the same as that of the 3rd example.

[0050] thus, the outgoing-radiation light from one optical fiber 96 — **** for interference fringe irradiation and laser spot irradiation — since the amount of the expensive optical fiber 96 used is halved by things, the low cost endoscope for instrumentation can be offered

[0051] Next, the 5th example of this invention is explained concretely. The timing-chart view in which applying the drawing 13 or the drawing 18 to the 5th example of this invention, and the block diagram of a laser light source and the drawing 16 showing the block diagram of a computer, and, as for the cross section of an endoscope point and the drawing 15, showing the driver voltage (DC-AMP output voltage) of a piezo-electric element and the timing of a frieze of each frame memory for explanatory drawing of the whole configuration of endoscope equipment and the drawing 14, as for drawing 17, and the drawing 18 are explanatory drawings showing change of

[0052] As shown in drawing 13, the endoscope equipment for instrumentation 201 of the 5th example of this invention is equipped with the monitor 206 and the laser light source 207 which display the picture image from the light source for a lighting 203 and CCU204 to which the electronic endoscope 202 and this electronic endoscope 202 for instrumentation are connected, the computer 205 connected to aforementioned CCU204, and the computer 205.

[0053] It can detach [connector / light source / 214 / which was prepared at the nose of cam of the universal cable 213 which the above-mentioned electronic endoscope 202 has the insertion section 211 of ** length, and the control unit 212 of **** formed successively by the back end of this insertion section 211, and extended outside from this control unit 212] freely to the light source for a lighting 203, and can equip. A signal cable 215 and the optical cable 216 can extend from this connector 214, and the connectors 217 and 218 prepared in each edge can be connected to CCU204 and the laser light source 207, respectively.

[0054] The hard point 219 is formed at the nose of cam, the insertion section 211 of the above-mentioned electronic endoscope 202 adjoins this point 219, the bend 221 which can curve freely is formed, and the long elasticity section 222 is further formed in the back end of this bend 221. The above-mentioned bend 221 can curve now by operating the curve knob

223. prepared in the control unit 212. The above-mentioned computer 205 is connected with the keyboard 224.

[0055] Drawing 14 shows the cross section of the point 219 of the electronic endoscope 202. The laser spot projection unit 228 for making the luminescent spot is formed in interference fringe lighting within the limits of the image pick-up unit 226 for acquiring the light-guide fiber not to illustrate, the lighting lens section, and the picture image for illuminating an inspected object in the point 219 of the electronic endoscope 202, the interference fringe projection unit 227 which projects an interference fringe on a body side, and a body side. The above-mentioned image pick-up unit 226 has the solid state image pickup device 230 and the signal cable 231 for changing into an electrical signal the optical image which carried out image formation by the objective lens system 229 and the objective lens system 229.

[0056] The collimate lens 234 with which the above-mentioned interference fringe projection unit 227 makes parallel light injection light of this single mode fiber 232 to which the nose of cam was fixed with the single mode fiber 232 and the mouthpiece 233, The polarization beam splitter 235 separated and outputted to the light of two polarization components which intersect perpendicularly mutually from this parallel light, The projection lens 236 which projects the light which passed through this polarization beam splitter 235, It has the piezo-electric element 239 for making the variation rate of the mirrors 237 and 238 for giving the optical path difference for the light of aforementioned one polarization component to the light of the polarization component of another side, and one mirror 237 carry out in the orientation perpendicular [237th page of this mirror].

[0057] The piezo-electric element 239 attached in reflector 237a formed by the vacuum evaporationo formed in the rear face of the above-mentioned projection lens 236, the mirror 238, and the mirror 237 is attached in the point 219 through the electrode holder 241. In addition, reflector 238a is formed also in the rear face of a mirror 238 by vacuum evaporationo etc. The two above-mentioned mirrors 237 and 238 are arranged at the vertical both sides of a polarization beam splitter 235, a mirror 237 is distance(for example, referred to as M) - separated from a polarization beam splitter 235, and is arranged, and the mirror 238 of another side is arranged in contact with the top of a polarization beam splitter 235, for example, the thickness is N.

[0058] An electrode is attached in both sides of the above-mentioned piezo-electric element 239, to each electrode, it connects with the nose of cam of lead wire 242, a piezo-electric element 239 is driven from the drive circuit not to illustrate, and the variation rate of the position of a mirror 237 is carried out in the vertical orientation.

[0059] The optical component which the parallel light which passed through the above-mentioned collimate lens 234 penetrates a polarization beam splitter 235, and progresses along with optical-path A, It is reflected by the polarization beam splitter 235, and is reflected by the 1st mirror 237. Penetrate a polarization beam splitter 235 and it is reflected by the 2nd mirror 238. The light which progresses along with optical-path B to the light which is divided into the optical component which is furthermore reflected by the polarization beam splitter 235, and progresses like optical-path B, and progresses along with optical-path A If thickness (length) of the vertical orientation of a polarization beam splitter 235 is set to L After giving optical-path-length (optical path difference) D only with 2 [large] ($rL+sM+N$) (r and s are the refractive index of a polarization beam splitter 235 and the mirror 238), it is projected on a photographic subject (body side) side through both the projection lenses 236.

[0060] And an interference fringe which was shown in drawing 3 according to optical-path-difference D will be formed in a photographic subject side, the above-mentioned piezo-electric element 239 is driven further, and the variation rate only of the minute optical-path-difference delta D is carried out from this optical-path-difference D by making the variation rate of the position of a mirror 237 carry out in the vertical orientation. An interference fringe shifts and it enables it to search for the 3-dimensional configuration of a body side by the 4 bucket method by carrying out the variation rate only of this minute optical-path-difference delta D.

[0061] The above-mentioned laser spot projection unit 228 has the prism 246 for carrying out

the outgoing radiation of the convex lens 245 which changes the outgoing-radiation light from the optical fiber 244 and the optical fiber 244 into the predetermined diameter of the flux of light, and the aforementioned flux of light at an angle of predetermined. The nose of cam of the above-mentioned optical fiber 244 fixes to a pipe 248 through a mouthpiece 247, and this pipe 248 is fixed to a point 219.

[0062] Drawing 15 shows the block diagram of a laser light source 207. The outgoing-radiation light of semiconductor laser 80 branches to optical-path 83a and optical-path 83b by the beam splitter 82, after being changed into a parallel ray by the collimate lens 81. The light of optical-path 83a is condensed by the condenser lens 84 by the optical connector terminal for laser spot projection 85. Moreover, semiconductor laser 80 is driven by the constant-current control circuit 258. This constant-current control circuit 258 is controlled by the computer 205, through the D/A-converter circuit 59, and maintains an interference fringe at the suitable quantity of light. Other configurations are the same as that of the laser light source 7 of the 3rd example shown in drawing 8.

[0063] On the other hand, the internal configuration of the above-mentioned computer 205 is shown in drawing 16. The picture signal from above-mentioned CCU204 is inputted into the frame memories A, B, C, and D which constitute the frame memory section 251, and can be frozen to arbitrary timing with the signal from CPU of (the CPU& memory 252). Moreover, the variation rate of the piezo-electric element 239 included in the interference fringe projection unit 227 of the endoscope point 219 is controlled by the voltage by CPU through D/A converter 253 and DC-AMP254.

[0064] That is, by controlling the variation rate of a piezo-electric element 239 from a computer 205, optical-path-difference D to minute optical-path-difference ΔD of the above-mentioned optical-path A and optical-path B is changed, and the phase of an interference fringe can be set up arbitrarily. And the result of an operation by CPU is displayed on a monitor 206 through the graphic board 255.

[0065] The driver voltage to the above-mentioned piezo-electric element 239 and the timing of a frieze of frame memories A, B, C, and D are shown in drawing 17. The output voltage of DC-AMP254 impressed to a piezo-electric element 239 as shown in this drawing 17 is Phase as it is shown in drawing 18 so that it may be made to change stair-like and the phase (Phase) of the interference fringe projected on a body side may change every 90 degrees that is, A, B, C, and D determine that the output voltage of DC-AMP254 will change every 90 degrees.

[0066] Moreover, it is made to generate the frieze signal which memorizes a frieze picture image to frame memories A, B, C, and D, respectively as shown in drawing 16 where the Gentlemen phase of the interference fringe projected on a body side is stabilized. Thus, the driver voltage to a piezo-electric element 239 is changed in the shape of a phase, the phase of the interference fringe on a body side is changed every 90 degrees, the picture image for every Gentlemen phase is incorporated to the four sheet frame memories A, B, C, and D, and a solid configuration is searched for by performing data processing by CPU. This operation technique is the same as that of the 1st example. In addition, you may use actuators, such as SMA, instead of the piezo-electric element 239 of this example.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The whole endoscope equipment block diagram for instrumentation of the 1st example of this invention.

[Drawing 2] The cross section of an endoscope point.

[Drawing 3] The schematic diagram of 3-dimensional instrumentation.

[Drawing 4] The principle view of the instrumentation by the interference fringe.

[Drawing 5] The principle view of the ranging technique by the laser spot.

[Drawing 6] The block diagram of a laser light source.

[Drawing 7] The cross section of an endoscope point in the 2nd example of this invention.

[Drawing 8] The block diagram of the laser light source in the 3rd example of this invention.

[Drawing 9] The block diagram of a part of laser light source in the modification of the 3rd example.

[Drawing 10] Front view showing arrangement of each optical system at the nose of cam of an endoscope in the 4th example of this invention.

[Drawing 11] The cross section showing the A-A cross section of drawing 10.

[Drawing 12] The block diagram showing the interior of the laser light source in the 4th example.

[Drawing 13] The whole endoscope equipment block diagram for instrumentation of the 5th example of this invention.

[Drawing 14] The cross section of an endoscope point in the 5th example.

[Drawing 15] The block diagram of a laser light source.

[Drawing 16] The block diagram of a computer.

[Drawing 17] Explanatory drawing showing the driver voltage to a piezo-electric element, and the timing of the frieze to four frame memories.

[Drawing 18] Explanatory drawing showing the relation of four phases of the interference fringe projected on a body side.

[Description of Notations]

1 — Endoscope equipment for instrumentation

2 — Electronic endoscope

3 — The light source for a lighting

4 — CCU

5 — Computer

6 — Monitor

7 — Laser light source

11 — Insertion section

19 — Point

26 — Image pick-up unit

27 — Interference fringe projection unit

28 — Laser spot projection unit

29 — Objective lens system

30 — Solid state image pickup device

32 — Plane-of-polarization store fiber

- 33 — Birefringence optical member
- 34 — Polarizing plate
- 35 — Projection lens
- 41 — Optical fiber
- 42 — Convex lens
- 43 — Prism

[Translation done.]

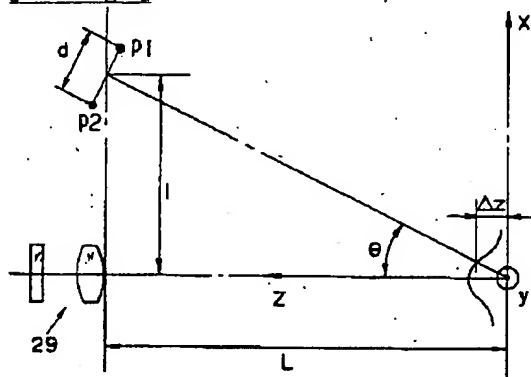
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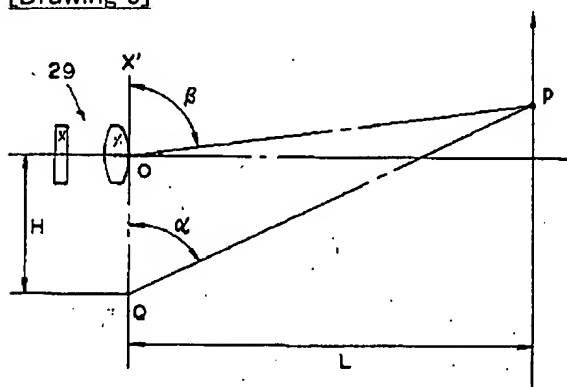
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DRAWINGS

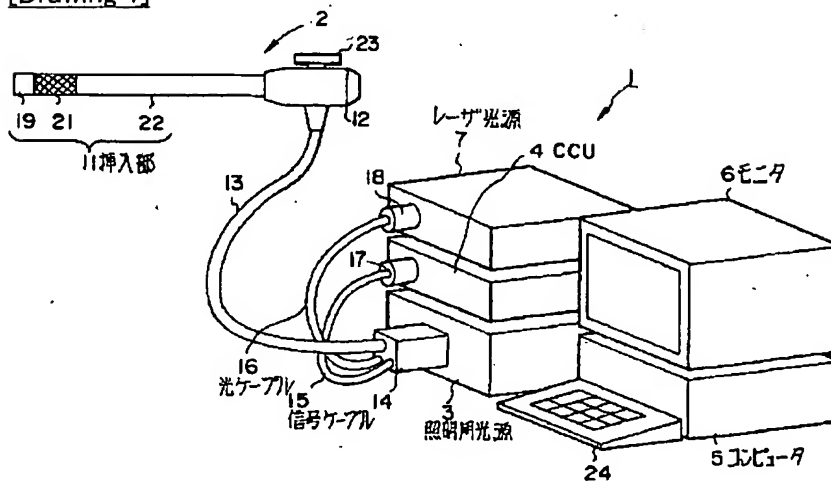
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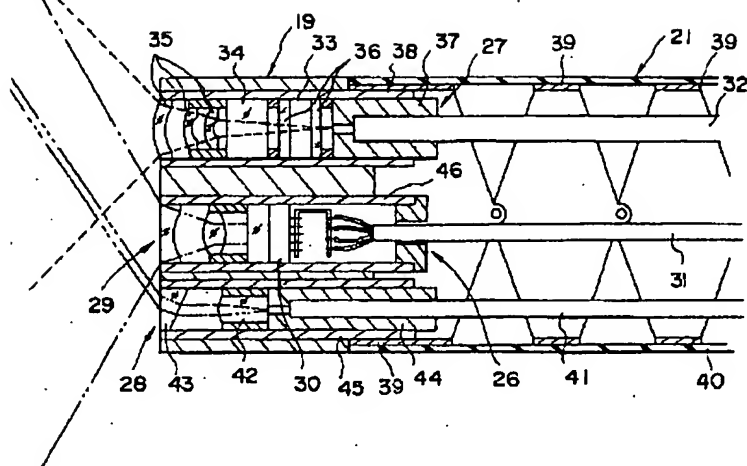
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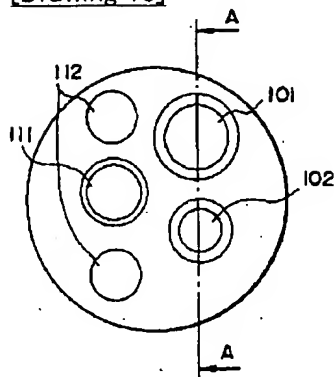
[Drawing 1]



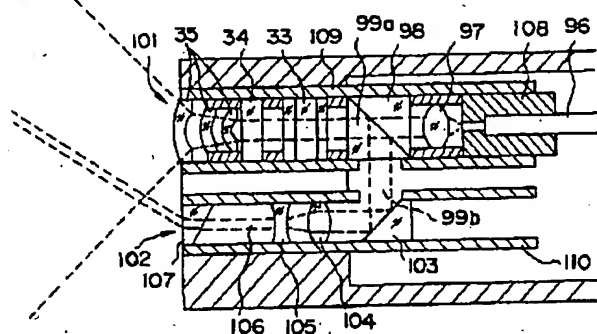
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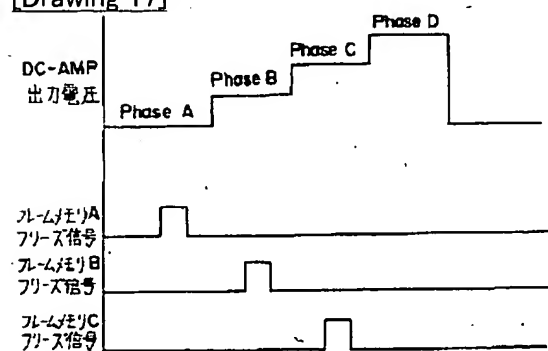
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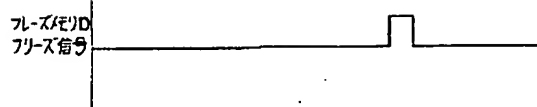


[Drawing 11]

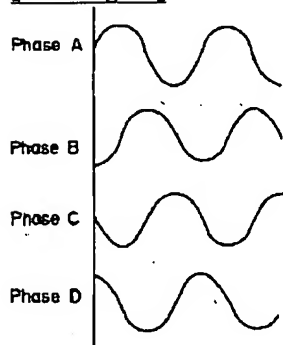


[Drawing 17]

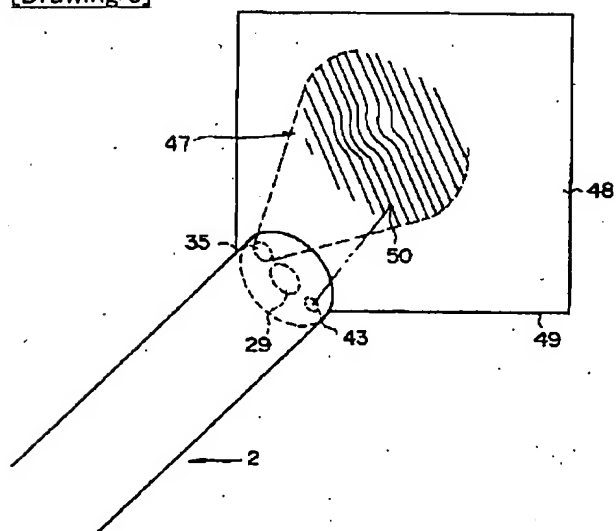




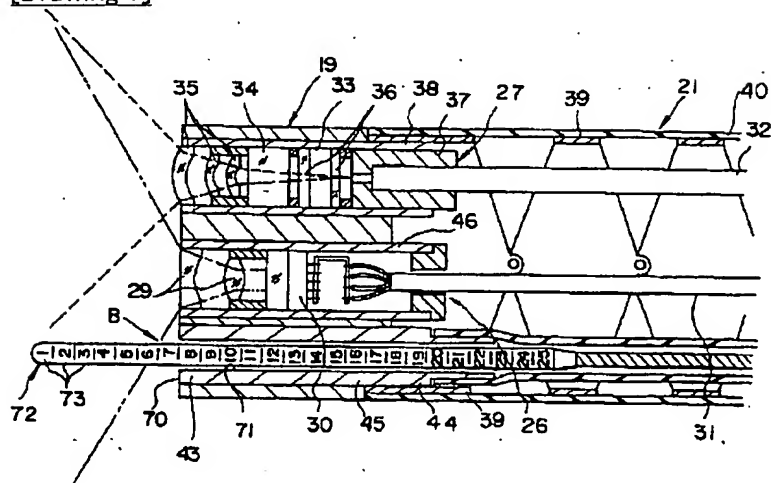
[Drawing 18]



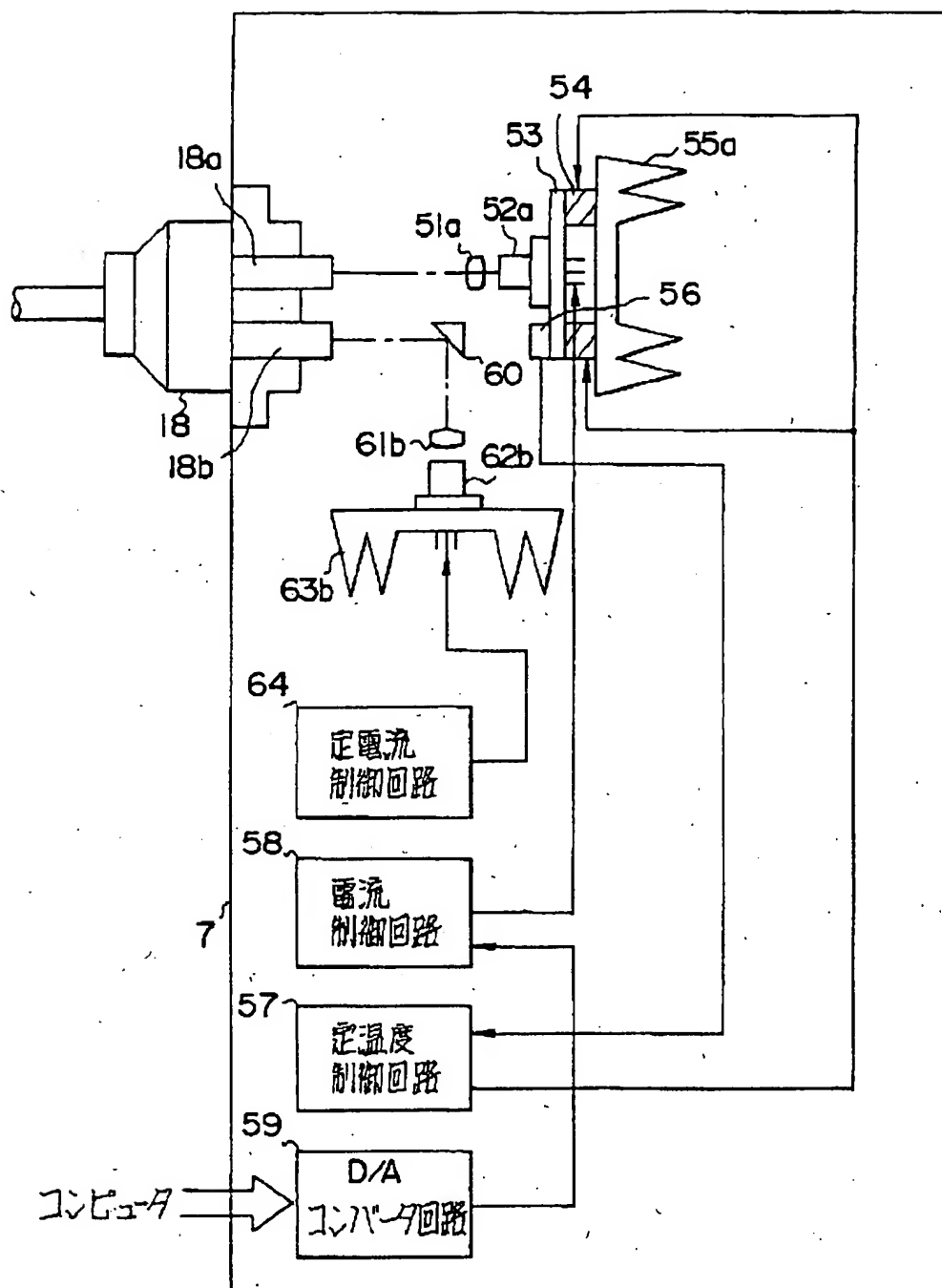
[Drawing 3]



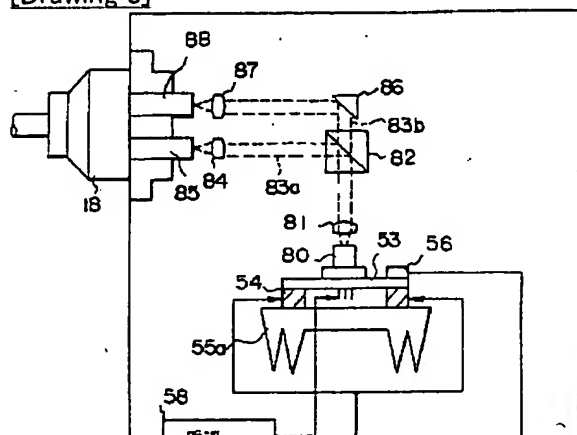
[Drawing 7]

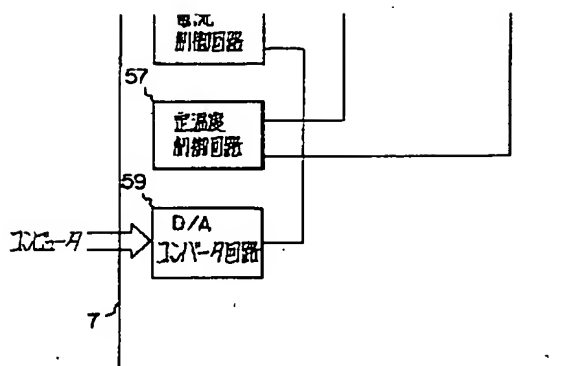


[Drawing 6]



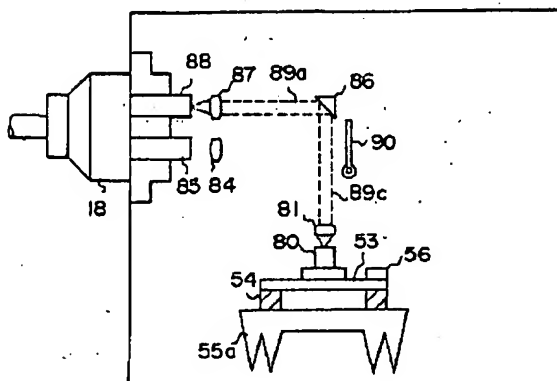
[Drawing 8]



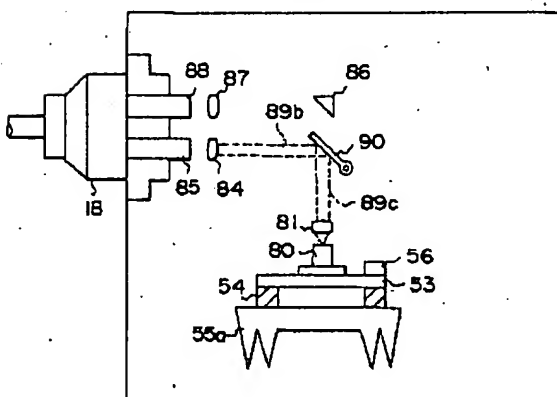


[Drawing 9]

(a)

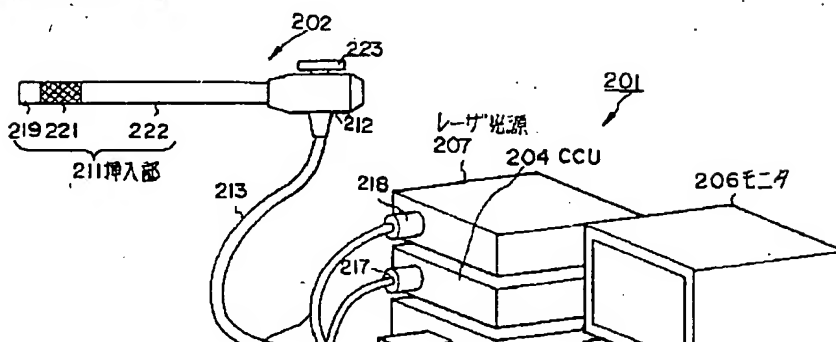


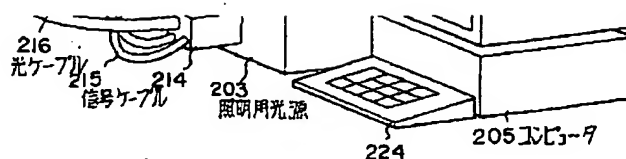
(b)



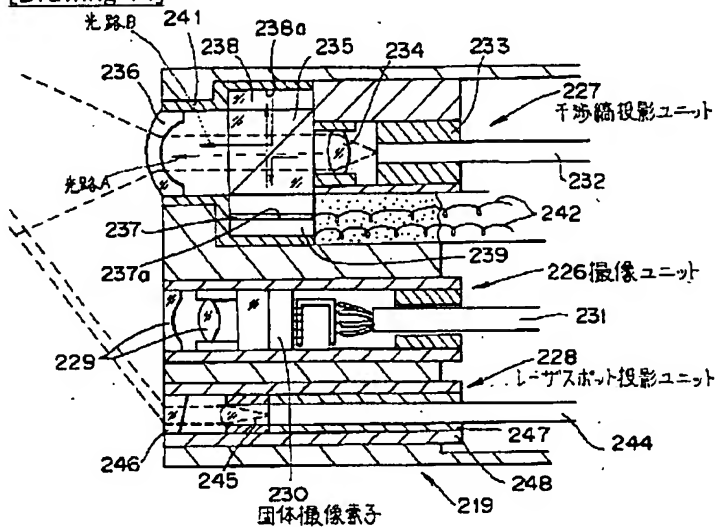
[Drawing 12]

[Drawing 13]

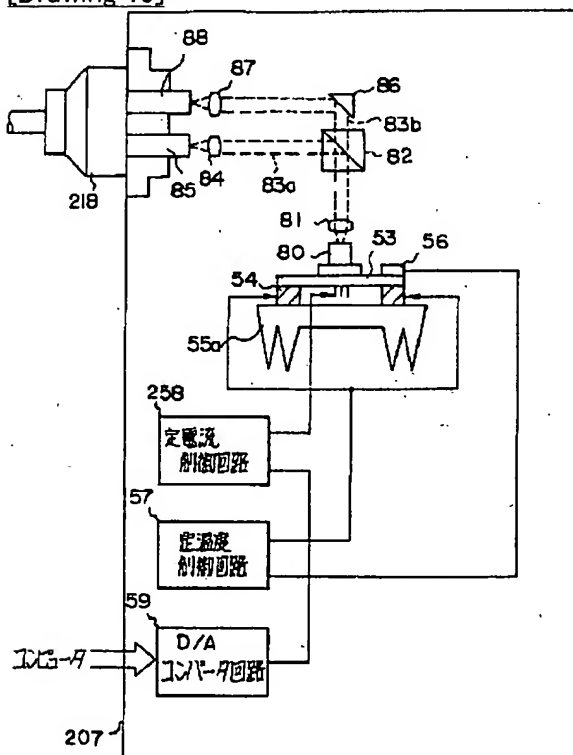




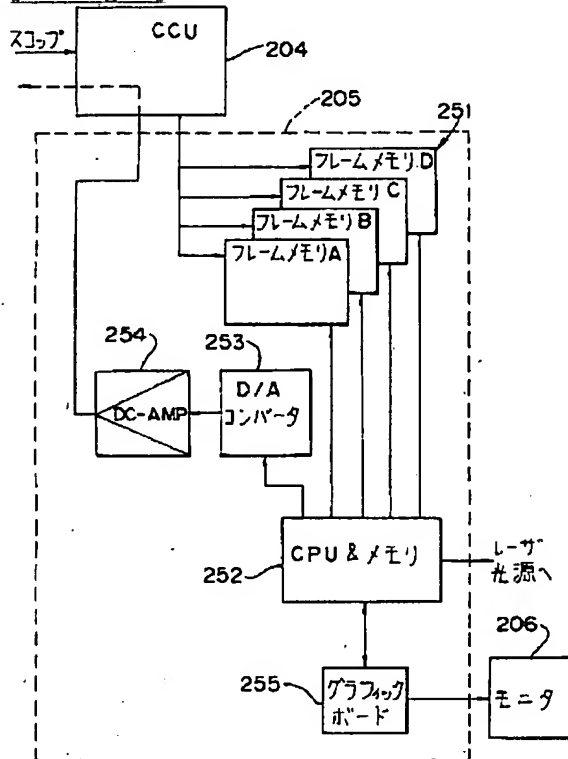
[Drawing 14]



[Drawing 15]



[Drawing 16]



[Translation done.]

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